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WATER SUPPLY AND WATER QUALITY CONTROL STUDY BIG WALNUT, BIG BLUE, AND DOWNEYVILLE RESERVOIRS WABASH RIVER BASIN INDIANA

Federal Water Pollution Control Administration
Evansville, Indiana

March 1966

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WATER SUPPLY AND WATER QUALITY CONTROL STUDY
BIG WALNUT, BIG BLUE, AND DOWNEYVILLE RESERVOIRS
WABASH RIVER BASIN
INDIANA

Abstract

A study has been made which discloses a need for storage in the proposed reservoirs for municipal water supply and for water quality control. These conclusions are based on analysis of existing water quality information and hydrologic, economic, and demographic analyses. Future needs are projected to the year 2020.

Prepared at the request of the District Engineer
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
Corps of Engineers
Louisville, Kentucky

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
Ohio River Basin Project
Evansville Field Station, Indiana

March 1966

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I. INTRODUCTION

Request and Authority

The Corps of Engineers, Louisville District, is preparing a comprehensive study of the Wabash River Basin concerning the development of water and related land resources. This study, as outlined in the "Plan of Survey, Wabash River Basin," September 23, 1963 (revised May 1964), requests the Public Health Service to determine present and future needs for and value of storage for municipal and industrial water supply and for regulation of streamflow for the purpose of water quality control.

This study has been made in accordance with the Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare, relative to the Water Supply Act of 1958 as amended (43 U.S.C. 390b) and the Federal Water Pollution Control Act as amended (33 U.S.C. 466 et seq.).

Purpose and Scope

The purpose of this study is to determine the need for and value of storage of water for the purpose of municipal and industrial water supply and for water quality control, which could be served by the proposed Big Walnut, Big Blue, and Downeyville Reservoirs in the White River Basin of Indiana.

The period of study for this report is from the present to the year 2020. This is the period for which the economic guidelines were established by the Corps of Engineers Ohio River Division "Projective Economic Study of the Ohio River Basin" and consequent economic studies of the Wabash River Basin.

The area studied includes 16 counties in central Indiana which most nearly approximate the drainage boundaries of the upper White River Basin and upper East Fork White River Basin.

Acknowledgments

Completion of this study was made possible by the cooperation and assistance of Federal and State authorities and by local authorities in the basin. Information and data were furnished from their publications, records, and files.

Acknowledgment is made of the assistance given by the following agencies:

U. S. Geological Survey - Indianapolis, Indiana

U. S. Soil Conservation Service - Indianapolis, Indiana

U. S. Bureau of Sport Fisheries and Wildlife - Lebanon, Ohio

Indiana State Board of Health

Indiana Stream Pollution Control Board

Indiana Department of Natural Resources

Indianapolis Water Company

Indianapolis Sanitary District

City of Greencastle

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The proposed Big Walnut, Big Blue, and Downeyville Reservoirs in the Wabash River Basin, Indiana, are being studied by the Corps of Engineers for the purposes of flood control, general recreation, fish and wildlife recreation, water conservation, and water quality control. The reservoir sites are, respectively, on Big Walnut Creek, a tributary of Eel River in the White River Basin, five miles northeast of Greencastle, Indiana; on Big Blue River near the Rush-Hancock County lines; and on Flatrock River, approximately seven miles northwest of Greensburg, Indiana. The latter two reservoir sites are on major tributary streams of East Fork White River.

2. The study area consists of approximately 5,200 square miles in central Indiana, generally centering on Indianapolis, and includes 16 counties which most nearly correspond to the hydrologic boundaries of the upper White and upper East Fork White River Basins.

3. The 1960 population of the study area was approximately 1,340,000, of which 980,000 were in the 3 counties of Marion, Delaware, and Madison which include the cities of Indianapolis, Muncie, and Anderson.

4. Water use from central water supply systems serving the area is 118 million gallons per day (mgd). This is approximately 121 gallons per capita per day (gpcd) for the 978,000 people served by these systems.

After adjusting for 32 mgd of the centrally supplied water utilized by industry, 88 gpcd is water used for domestic, commercial, and general public use. Self-supplied industrial water use is estimated at 575 mgd, of which 506 mgd is for thermal power plant cooling water.

5. The major communities in the area have secondary treatment plants. An estimated 735,000 people are served by municipal waste treatment plants. These plants have a raw Biochemical Oxygen Demand (B.O.D.) of 1,620,000 population equivalent, indicating a significant industrial waste loading, much of which is concentrated in Indianapolis. After treatment, these wastes have a population equivalent estimated at 270,000. In addition, self-discharging industries discharge treated wastes with a population equivalent estimated at 41,000.

6. The surface water in the study area is of the calcium-magnesium carbonate type with hardness generally in the range of 200 to 370 mg/l and alkalinity from 150 to 300 mg/l, which can be typified as hard and having a high alkalinity. Water quality is acceptable for all legitimate uses except below sources of waste discharges where insufficient flow exists to assimilate residual organics.

Conclusions

1. The population of the study area is projected to increase to approximately 1,720,000 by 1980 and to 2,515,000 by 2020. The urbanized area of Indianapolis is projected to increase in population to 900,000 by 1980 and to 1,300,000 by 2020.

2. Water requirements for municipal and industrial purposes, exclusive of that for thermal power plant cooling, are expected to increase to 265 mgd by 1980 and to 522 mgd by 2020. Approximately 90 percent of this requirement is expected for the metropolitan areas of Indianapolis, Muncie and Anderson, and the immediately adjoining counties.

3. Storage proposed for conservation purposes in these reservoirs is capable of supplying some of the water supply needs for the year 2020. Big Walnut Reservoir storage can supply such needs for 1.0 mgd at Putnamville State Farm and 78 mgd for the Indianapolis metropolitan area. Big Blue Reservoir conservation storage is capable of providing approximately 28 mgd for the Indianapolis area. Downeyville Reservoir storage is capable of providing an anticipated need for 2.4 mgd of additional water supply at Greensburg.

4. Provision of water quality control from the Big Walnut and Big Blue Reservoirs will serve to protect existing sport fishing values, protect the public health aspects of use of the stream for public water supply and general recreation, result in a better and more economical source of water supply, thereby serving to encourage municipal and industrial development, protect downstream land values, and protect and enhance esthetic values. The benefits of providing water quality control are widespread.

5. To maintain adequate water quality in downstream reaches through 2020 is estimated to require annual draft-on-storage*, at the point of need, of 1,400 acre-feet for Big Walnut Creek below Greencastle,

*Annual draft-on-storage is the sum of the incremental excesses of needed releases over inflows during a climatic year.

12,000 acre-feet for Big Blue River below Shelbyville, 80,000 acre-feet for White River below the Muncie-Anderson area, and 11,000 acre-feet for East Fork White River below Columbus.

6. Thermal stratification may be expected to occur in the Big Walnut, Big Blue, and Downeyville Reservoirs with reduction of dissolved oxygen in the hypolimnion. To assure discharge of good quality water below the dams, it is recommended that sufficient multiple-level outlets be provided to insure selection of the best quality water available.

7. In determining releases for water quality control, the quantity and quality of release should be based on use of a water quality monitoring system and use of anticipated flows from the U. S. Weather Bureau River Forecast Section.

8. The minimum annual value of storage in Big Walnut Reservoir for water supply purposes is $553,500. Of this, $3,500 is for meeting a 2020 need of 1.0 mgd additional water supply at Putnamville State Farm and $550,000 for meeting 78 mgd of the water supply need in the Indianapolis metropolitan area. The minimum annual value of storage in Big Blue Reservoir is $81,000 for meeting 28 mgd of the water supply need for the Indianapolis metropolitan area. The minimum annual value of storage in Downeyville Reservoir is $6,500 for meeting a 2.4 mgd additional water need in 2020 for Greensburg. Needs for additional water supply exist for the New Castle and Muncie-Anderson areas.

However, since annual pipeline and pumping costs would exceed nearby reservoir development costs, no benefit exists for satisfying these needs from the proposed reservoirs.

9. The minimum annual value of the benefits of supplying reservoir storage for water quality control in Big Walnut Reservoir for the Big Walnut Creek and Eel River is $22,300. The minimum annual value of benefits of providing water quality control from Big Blue Reservoir for Big Blue River below Shelbyville is $75,000.

10. The benefit values used are based on the most likely alternate to providing storage in the proposed reservoirs. Annual benefits are based on a 50-year amortization of capital costs at 3 1/8 percent plus estimated operation and maintenance costs.

11. These needs and the value of benefits are based on the best estimates that can be made at this time and are subject to review and revision based on information and data from the Ohio River Comprehensive Study by the Department of Health, Education, and Welfare when it becomes available.

III. PROJECT DESCRIPTION

Location

Potential reservoir sites in the study area are on Big Walnut Creek in Putnam County, Indiana, approximately 5 miles northeast of the city of Greencastle; on Big Blue River near the Hancock-Rush County lines and about 21 miles southeast of downtown Indianapolis; and Downeyville Reservoir on Flatrock River in Decatur County approximately 7 miles northwest of Greensburg, Indiana. These potential reservoir site locations are shown in Figure I at the end of this report. All reservoir sites are in the White River Basin which is a major tributary of the Wabash. Big Walnut Creek is a tributary of Eel River in the main stem White River Basin. Big Blue and Flatrock Rivers are major headwater streams of the East Fork White River Basin.

Streamflow

The drainage area above the Big Walnut Creek damsite is 197 square miles. The only gaging station on Big Walnut Creek is at Reelsville about 22 miles below the proposed damsite. At the gage the drainage area is 338 square miles. Based on the use of calculated flow frequencies at Reelsville and miscellaneous flow information, the following is the flow expectation at the damsite:

Mean streamflow	204 cfs
Minimum 7 consecutive day mean flow with a 10 year recurrence	Less than 2 cfs
Minimum 1 day once in 30 year mean flow	Less than 1 cfs

The drainage area above the Big Blue damsite is 268 square miles. Flow records are available from USGS gaging stations on Big Blue River at Carthage, with a drainage area of 187 square miles, since 1950; and at Shelbyville, with a drainage area of 425 square miles, since 1943. Flows expected at these stations are listed below:[1]

	Big Blue River Flow in cfs	
	Carthage	Shelbyville
Mean streamflow	196	463
Minimum 7 consecutive day mean flow with a 10 year recurrence	19	37
Minimum daily discharge during period of record	18	32

The drainage area above the Downeyville damsite is 284 square miles. A USGS gaging station on Flatrock River has been in operation at St. Paul since 1931. The drainage area at the gaging station is 298 square miles. Flows expected at this station are:[1]

Mean streamflow	315 cfs
Minimum 7 consecutive day mean flow with a 10 year recurrence	1.3 cfs
Minimum 1 day mean flow with a 30 year recurrence	0.5 cfs

Water Quality

Water quality records are not available on Big Walnut Creek. Quality records are available, from the Indiana State Water Monitor Network, for the period since 1957 at Worthington at the mouth of the

Eel River (drainage area approximately 1,100 square miles). Table III-1 (see Appendix) shows the record at this station for the year 1964. The sanitary water quality at the project site may be expected to be better than at Worthington, since the treated wastes of Greencastle, Brazil, and Jasonville enter the stream between the two points. Untreated sewage from Jamestown (1960 pop. 827) and North Salem (1960 pop. 626) is discharged into tributaries of Big Walnut Creek approximately 20 miles upstream from the project site. The area above the damsite is almost completely rural at present with no population centers over 1,000 and no significant industry. Adverse effects of organic wastes would not be expected in Big Walnut Creek Reservoir.

Water quality records are available on the Big Blue River at Carthage approximately 8 stream miles above the project site, at Morristown approximately 2 miles below the project site, and at Shelbyville approximately 12 stream miles below the project site. Indiana Water Quality Monitor Station records for 1964 are shown in Tables III-2, III-3, and III-4 for these stations. In addition, percent occurrence plots for B.O.D., D.O., chlorides, nitrates, and coliform are shown for the Carthage and Shelbyville stations for the period 1957 to 1964 in Figure V. The Shelbyville station shows higher D.O. and B.O.D. levels, while the Carthage station has higher levels for chlorides, nitrates, and coliform. New Castle (1960 pop. 20,349) near the headwaters of Big Blue River is by far the largest community introducing wastes above the Shelbyville station (both the Shelbyville and Carthage stations are above the point of local treated waste discharges); therefore, domestic

wastes are a more predominant feature for the upstream Carthage station and serve to explain the higher chloride and coliform concentrations at Carthage. The higher B.O.D. levels at Shelbyville are presumed to be due largely to the discharge of treated industrial wastes from a paper mill at Carthage. The company uses pulp wood to manufacture paper for corrugated media. The wastes from this process consist mainly of cooking liquor and machine water. The cooling liquor is burned in a thermoreactor and the ash is reclaimed. The machine water is treated in a Sveen-Pedersen flotation unit, and the effluent is discharged to the river during the period of about October to May. During the remainder of the year, the company discharges this water to a 55-acre lagoon system for release at periods of high streamflow in accordance with dilution rates established by the Indiana Stream Pollution Control Board. The company monitors the river daily to show the effect of waste discharges and submits the data to that Board. As a free flowing stream, the river can assimilate the treated wastes from the paper mill. Reservoir construction would convert this stream stretch to an impounded area with lower assimilative characteristics. Construction of a pipeline to carry the treated wastes of this paper mill to a point below the dam should be considered. If this were not done, the treated effluent would discharge approximately one mile above the head end of the Big Blue Reservoir. With such a pipeline the nutrient load from municipal and industrial wastes (mostly from New Castle) should not be sufficiently great to cause other than a localized problem in the upper arm of the reservoir, and then only during low flow periods. The State of Indiana specifies secondary treatment with chlorination of wastes upstream from

reservoir areas. Treatment facilities in close proximity to reservoirs will be required to provide chlorination and holding ponds or other treatment beyond secondary. Under these conditions of a high level of upstream treatment and bypassing of the paper mill effluent, quality in Big Blue Reservoir should be satisfactory to allow use of the reservoir for general recreation, fish and wildlife recreation, and water supply.

Without the bypass pipeline, use of reservoir storage for water supply would be impaired by higher treatment costs. Use for general recreation would be impaired by possible color problems and nutrients creating a less esthetically desirable pool area. Use for fish and wildlife recreation would be somewhat impaired by a possibly significant portion of the upstream reservoir volume being deficient in D.O. and having suspended solids in sufficient concentration to interfere with fish life. In addition during winter stratification, zero or low dissolved oxygen levels in the reservoir would extend further up in the hypolimnion.

The maximum mean sea level flow elevation of the existing lagoons is about 863. The proposed flood control pool elevation is 880. These lagoons are constructed in the glacial sand and gravel deposits along the stream and have sealed themselves. Hydrostatic pressure from the head differential during storage of floodwaters could cause infiltration from the reservoir into the lagoons and a disruption of the bottom seal of the ponds and consequent pollution of the reservoir. It is

therefore believed that it will be necessary to replace the existing lagoons at an elevation above the influence of the proposed reservoir. It will also be necessary that the organic solids be buried above elevation 880 and sealed with at least 6 inches of compacted clay. The lagoons which have a storage volume of 440 acre-feet (55 acres surface area and 8 feet of depth) could be replaced either at a point below the proposed reservoir or near the present Container Corporation site. The latter would more conveniently keep the lagoons under the operating control of the Corporation. Means to provide a significant lagoon discharge during release of flood waters would be necessary. With lagoons near the plant, a reregulation lagoon would be necessary below the dam. A capacity of 90 acre-feet should be sufficient for a reregulating lagoon.

Since present operation of the lagoon system is directly related to the stream hydrograph, regulation will require a different operation and close cooperation. Problems to be considered include B.O.D. and resulting D.O. and color. The effects of the reservoir on these pollutants are discussed separately below.

B.O.D.

Introduction of treated wastes with a residual B.O.D. demand at a point approximately six miles further downstream should not in itself cause a stream problem. Stream gradients and reaeration capabilities are believed to be approximately equal to that in the reach where

assimilation is now accomplished. Since the critical point will be at a point with a drainage area of 290 square miles rather than 268 square miles, a greater volume of flow will be available annually at the new critical reach. This additional flow will not all be available for assimilation because lagoon releases are normally made only during the cooler months, and some of the winter and spring flow will be stored for water quality releases mainly in summer and early fall (see water quality storage needs in Chapter VIII). During the more severe drought years there will be no gain of volume of flow at the critical point by discharging at a further downstream point. However, in most years there should be a marginally greater volume of flow for assimilation of treated wastes. Perhaps more important is a net gain from regulation in synchronizing assimilative flow to lagoon release by having a more predictable hydrograph. Purely from a consideration of assimilation of B.O.D., the reservoir should have no adverse effect on the Big Blue River if the wastes are diverted around the reservoir.

Color

Color is a more critical problem than B.O.D. Present operation limits downstream color to 38 units during nonturbid conditions. As for B.O.D., a marginally greater volume of assimilative flow and a greater ability to synchronize lagoon and streamflows should assist in protecting legitimate stream uses. Less turbidity during periods of high runoff from clarification in the reservoir will hinder discharge

of colored wastes since D.O. is presently the only criterion necessary during periods of high turbidity. The reservoir, however, because of site limitations will have a relatively small storage for the drainage area involved and much turbidity can still be expected in release flows of stored floodwaters. Study of color and turbidity in the streamflow below Mansfield Reservoir in Indiana indicates an apparent decrease in color and turbidity since reservoir construction. Reduction of color will benefit assimilation of colored wastes while, as previously discussed, reduced turbidity will be detrimental to the present type of operation.

Based on an analysis of the many factors enumerated above, it is believed that construction of Big Blue Reservoir can be accomplished and wastes from the Container Corporation Plant accommodated as satisfactorily after reservoir construction as at present with unregulated streamflow. It will be necessary in advanced planning stages that reservoir operation schedules be devised in such a manner that all legitimate stream uses can be protected to the utmost. Federal, State, and local interests should cooperatively formulate an operating schedule to effect this objective.

Water quality information in the Flatrock River Basin is limited. The State of Indiana does not have a water quality monitor station in this basin. Water quality data during low flow periods of 1964, obtained by the Evansville Field Station, Ohio River Basin Project, are shown in Table III-11. The results indicate a nondegraded condition with relatively high hardness, typical of base flow from the glacial

sands and gravels of the region. Above the proposed Downeyville Reservoir, the only major community is Rushville (1960 pop. 7,264). Organic wastes from Rushville are attributable to the resident sewered population. Rushville has a secondary sewage treatment plant. The major industry in Rushville is furniture manufacturing and the production of piston rings, neither of which would contribute a noticeable organic waste loading. It is concluded that under existing upstream residential and industrial development, no adverse effects of organic wastes or nutrients would result in Downeyville Reservoir. Upstream waste control policies of the Indiana State Board of Health should prevent future waste loadings from appreciably changing these conditions.

Pertinent Data

The proposed projects are being considered for flood control, municipal and industrial water supply, water quality control, general recreation, and fish and waterfowl recreation. Pertinent data based on preliminary planning information are given below.

	Pool Elevation			Capacity in Acre-Feet		
	Big Walnut	Big Blue	Downeyville	Big Walnut	Big Blue	Downeyville
Flood Control	782-808	863-880	895-910	160,000	75,100	71,300
Conservation	726-782	850-863	857-895	153,000	31,500	75,500
Minimum	726	850	857	10,000	13,500	15,100
Total Storage				323,000	120,100	161,900

The drainage areas at the three proposed damsites are 197 square miles at Big Walnut, 269 square miles at Big Blue, and 276 square miles at Downeyville.

IV. STUDY AREA DESCRIPTION

Location and Boundaries

The study area consists of the counties of Clay, Putnam, Owen, Hendricks, Morgan, Marion, Johnson, Hancock, Hamilton, Madison, Delaware, Randolph, Boone, Henry, Shelby, and Rush in central Indiana. This area includes essentially the entire Eel River Basin, the entire East Fork of White River Basin above Columbus, and the White River Basin from its headwaters through the downstream reach below the Indianapolis metropolitan area.

The area under study consists of approximately 5,200 square miles, of which 1,100 square miles are in the Eel Basin; 1,692 square miles are in the East Fork White River Basin above Columbus; and 2,400 square miles are in the White River Basin between the Eel and East Fork drainage basins (see Figure I in the Appendix for a study area map). In addition, subarea maps for the Eel, East Fork White River, and White River areas are designated Figures II, III, and IV, respectively. (See Appendix.)

Geography and Topography

The northern two-thirds of the study area including all of Hendricks, Marion, Hamilton, Madison, Delaware, Randolph, Boone, Hancock, and Henry Counties and northern portions of Putnam, Morgan, Johnson, Shelby, and Rush Counties are in the Tipton till plain physiographic region. The Tipton till plain is a great glacial plain occupying nearly one-third of the State of Indiana. It is characterized by a variable covering of glacial material, the surface of which is mainly flat or very gently

rolling. Stream gradients are generally in a range greater than three feet per mile. The White River in Marion and Morgan Counties is about 175 feet below the till plain. The plain has a general westward slope. The southern edge of the Tipton till plain is the general limit of Wisconsin glaciation.[2]

The southern third of the study area is divided between six physiographic regions. The terrain in this area is generally more rugged than in the Tipton till plain area. Southern Putnam County, Owen County, and southern Morgan County areas are from moderately to very rugged, while the Clay County area to the west and Johnson, Shelby, and Rush County areas to the east have generally level to moderately rolling terrain.

Climate

The study area has a humid continental type climate. There is a sharp contrast between winter and summer temperatures. The annual mean temperature during 33 years of record at the Indianapolis Airport is 52.1°F. Mean monthly temperatures have a range of from 75.2°F in July to 29.1°F in January. Average annual precipitation at the Indianapolis Airport is 39.25 inches. Mean monthly precipitation ranges from 2.28 inches in February to 4.62 inches in June.

Principal Communities and Industries

In the Eel River-Big Walnut Creek Basin, there are only two communities of over 2,500. These are Greencastle (1960 pop. 8,506) and

Brazil (1960 pop. 8,853). Greencastle is a farm market town and is the site of a business form production plant and an electronic capacitor plant. DePauw University is situated here. Brazil has a clay products industry and is influenced by Terre Haute 17 miles away. There are active coal mines near Brazil as well as throughout southern Clay County and western Owen County.

In the East Fork of White River Basin above Columbus there is a well-diversified industrialization. Canning, pharmaceuticals, fabricated metals, electrical machinery, automotive machinery, and paper products are important. The major communities are New Castle, Shelbyville, Greenfield, Rushville, and Franklin, all with a population of between 7,000 and 21,000 in 1960. In addition to the industrial base, there is a well-diversified agricultural development and most of the communities are within a reasonable commuting distance to job opportunities in Indianapolis.

In the White River Basin area, Indianapolis is the dominant population and industrial center. Indianapolis is located in Marion County and is the capital of Indiana. In 1960, Indianapolis had a population of 476,000 while Marion County had a population of nearly 700,000. Indianapolis is a major industrial and commercial area and is a transportation hub. Food processing, fabricated metals, pharmaceuticals, and automotive and electrical machinery are major industries.

Anderson (1960 pop. 49,100) has over half of its industrial employment in the electrical machinery and equipment categories. Another important category is fabricated metals.

Muncie (1960 pop. 68,600) is highly industrialized. Major industries are automotive transmissions and batteries, meat packing, food and beverage containers, and metal fabrication. Muncie is also the site of Ball State University.

Other communities in this White River area are Greenwood, Mooresville, Martinsville, Brownsburg, Danville, Noblesville, Plainfield, Speedway, Beech Grove, and Lawrence, all with a 1960 population of from 3,000 to 11,000. These communities are either suburban to Indianapolis or within a 30-mile commuting distance. They are generally showing a distinct growth pattern due to job opportunities in nearby Indianapolis. Some of these communities in addition have a small industrial base. Alexandria, Elwood, Tipton, and Winchester, all with a 1960 population in the 5,000 to 12,000 range, are in the northern portion of the study area and are within 30 miles of either Muncie or Anderson. In these latter communities as well as in the smaller communities near Anderson and Muncie, canning, glass containers, and building products are major industries.

V. WATER RESOURCES OF THE STUDY AREA

Quantity of Water Available

The mean streamflow in the study area is equal to an average annual runoff of from 12 to 15 inches. During low flow periods considerable variation exists between various streams, depending largely on local geology. The following tabulation shows the dependable flow at gaging points on various streams in the study area. There is a considerable variation in dependable low flow yields on a cfs per square mile basis. The variation is largely dependent on local geology and the thickness and permeability of glacial deposits. Inflow from and loss to pre-glacial stream valleys greatly affects low flows. The Big Blue River and White River have relatively high low flow yields. These streams have an origin in a more northernly area than the Eel River and Flatrock River, which have moderate and relatively small low flow yields respectively.

The largest existing reservoir in the study area is the Corps of Engineers Cagles Mill Reservoir on Mill Creek, a tributary of Eel River (see Figure I in the Appendix). This reservoir provides flood control and recreation benefits. No water supply or water quality control storage is included in the storage allocation. Operation does not provide for flow augmentation for water supply or water quality control.

The Indianapolis Water Company has impoundments on two tributaries of White River. Morse Reservoir, with a storage capacity of 21,000 acre-feet, supplements natural flows in the White to provide an estimated

Location	Years of Record	Drainage Area Square Miles	Mean Flow cfs	Lowest Average Flow in cfs for Indicated Number of Consecutive Days for Indicated Recurrence Interval in Years*		
				7 Day Once in 10 Years	3 Day Once in 20 Years	3 Day Once in 30 Years
Eel River at Bowling Green	1931-63	844	853	17.0	12.0	11.0
Big Walnut Ck. near Reelsville	1950-63	338	350	6.1	4.4	
White River near Centerton	1930-32 1946-63	2,435	2,366	125.0	93.0	
White River near Nora	1930-63	1,200	1,077	70.0	55.0	51.0
Blue River at Carthage	1950-63	187	196	19.0		
Blue River at Shelbyville	1943-63	425	463	37.0	33.0	
Driftwood River near Edinburg	1940-63	1,054	1,129	60.0	42.0	
Flatrock River at St. Paul	1930-63	298	315	1.3	0.6	0.5
Sugar Creek near Edinburg	1942-63	462	490	16.0	11.0	

* All indicated values are from "Low-Flow Characteristics of Indiana Streams," U. S. Geological Survey and State of Indiana.

firm yield of 75 mgd at the water company's diversion canal about 2 miles south of Nora in Marion County. Geist Reservoir, with a storage capacity of 21,000 acre-feet, supplements natural flows in Fall Creek to provide an estimated firm yield of 20 mgd. The estimated firm yields are based on engineering appraisals for the Indianapolis Water Company and reflect the dependable ensured flows during the worst drought of record.

The Muncie Water Company has a 21,000 acre-foot impoundment on Prairie Creek. This impoundment plus natural flows in Buck Creek and White River provide a 17 mgd firm water supply yield. Ground water is a significant source of existing and potential water supply. Except for Muncie and Indianapolis Water Company, virtually the entire public water supply in the study area is from ground water sources. Most of the self-supplied industrial water supply is from ground water sources.

Outwash deposits of Wisconsin age and to a lesser extent of Illinoian age occur along the Eel River, White River, Sugar Creek, Blue River, Brandywine Creek, and Flatrock River. The outwash is capable of moderate to large yields of water. Most of the length of the outwash filled valleys is occupied by perennial streams. Ground water pumpage in these areas reduces streamflow. In the headwater stretches of the smaller tributaries the amount of induced infiltration is small, especially during dry weather. At such times the streamflow represents ground water discharge. Within the study area quantities of ground water capable of significant development exist in the Eel River Basin from the valley of Big Walnut Creek about two miles north of Greencastle to the mouth of

Eel River, along White River throughout the entire length within the study area, and along the major streams in the East Fork Basin. Estimated use in 1963 from these sources in the study area was 92 mgd, of which 58 mgd was for municipal and industrial water supply in Marion County.

In addition to the major ground water resource from outwash deposits, bedrock development of Pennsylvanian and Mississippian age generally yield sufficient water for farm and stock use and locally enough for municipal and industrial supply. Developed use of municipal and industrial water supply in the study area from these sources is small, and future development will probably be limited by the greater water availability from surface supplies and from ground water originating in outwash deposits.

From the ground water literature researched, an estimate of maximum potential yield from ground water sources in the study area was obtained only for Marion County. The ground water quantity in Marion County believed to be perennially available is about 235 mgd.[3] Perennially available has been defined as not necessarily "economically developable." Development of ground water in Marion County decreases surface flow in the White River because of some recharge that would occur from the river to the adjoining sand and gravel and bedrock aquifers.

Considerably less ground water is available in Randolph, Hendricks, and Boone Counties than in Marion County because of more limited glacial outwash deposits. In Clay, Putnam, Johnson, Hancock, Shelby, and

Rush Counties ground water is assumed to be available in considerable quantities but less than that available in Marion County. In these counties outwash deposits exist but appear to be of lesser magnitude and are adjacent to smaller streams than the White River in Marion County. Northeast Putnam County, central Johnson County, and southern and central portions of Rush County would not appear to be favorably located for obtaining large quantities of ground water. Delaware, Madison, Hamilton, Morgan, and Owen Counties have significant quantities of ground water available along the White River.

Quality of Water Available

The quality of surface water in the study area is quite variable. The surface water supply can be characterized as hard (generally 200-400 mg/l hardness as $CaCO_3$). Quality of the surface supply below Indianapolis and Muncie is seriously affected by lack of sufficient streamflow to assimilate treated wastes. A similar though less severe situation occurs below New Castle on the Big Blue River, below Rushville on Flatrock River, and below Greenwood, Greenfield, Danville, Brownsburg, Brazil, Elwood, Alexandria, and Franklin on small tributaries during dry periods of the year. The streams generally have good assimilative and self-purification properties. The Eel River and the Big Blue River below Shelbyville generally have a water quality acceptable for all legitimate uses. Acid mine drainage is a problem on some small tributaries of the Eel River Basin. The acid mine drainage is not

great enough to noticeably affect the water quality of the Eel River as shown by records of the Indiana Water Quality Monitor station at Worthington at the mouth of Eel River (see Table III-1 in the Appendix).

The Indiana Water Quality Monitor Station Network has been in operation since 1957. For water quality information for 1964 on Eel River at Worthington, Big Blue River at Carthage, Morristown, and Shelbyville, and White River at Muncie, Anderson, Noblesville, Nora, Antrim, and Martinsville, see Tables III-1 through III-10 in the Appendix. The Antrim station is about 6 miles downstream from the discharge of Indianapolis' treated wastes,* while the Martinsville station is about 30 miles downstream from Antrim. The Carthage, Shelbyville, Muncie, and Anderson stations are above the discharge of the local waste treatment plants.

Ground water quality is shown in Table V-1 for various municipal supplies in the study area. Ground water sanitary quality is generally high. Chemical quality is typified as generally hard with some wells having objectionable quantities of iron or sulphur.

* A second Indianapolis waste treatment plant is scheduled for completion in mid 1966 and will discharge to the river just above the Antrim station.

VI. THE ECONOMY

Introduction

An investigation of the population and economic characteristics and a projection of the probable growth of the area of concern of the reservoir projects provide a basis for determining the water requirements in terms of both quantity and quality for the area. The growth of an area depends not only on the characteristics of the area itself but, also, in varying degrees, on the type and extent of the growth of the Nation and the region of which it is a part. This discussion of the economy has been prepared within the general framework of the Projective Economic Study for the Ohio River Basin prepared by the A. D. Little Company, Inc.[4]

To supplement that work, a special study has been conducted by the Louisville District of the U. S. Army Corps of Engineers, utilizing historical employment data from the unemployment insurance program of the Bureau of Employment Security, U. S. Department of Labor. This study covered the Wabash and White River Basins as delineated in the Projective Economic Study of the Ohio River Basin.

Present

The area of economic influence of the proposed Big Walnut, Big Blue, and Downeyville Reservoir projects encompasses 16 counties in central Indiana. The economic areas are in central Indiana and are divided into three hydrologic basins. The economic area of the Eel River Basin is made up of the counties of Clay, Owen, and Putnam. The economic area of the East Fork of the White River is made up of the counties of Hancock, Henry,

Rush, and Shelby. The largest economic area is the White River Basin proper and is made up of the following counties: Boone, Delaware, Hamilton, Hendricks, Johnson, Madison, Marion, Morgan, and Randolph.

Between 1950 and 1960, all the counties in the areas had a population increase except Owen County in the Eel River Basin. Estimates for the period 1960 through 1964 show a slight population decrease in Owen County.[5] In this same period, all the counties in the East Fork Basin except Rush County increased. All of the counties of the White River Basin proper also increased between 1960 and 1964. In general, the rural counties are just holding their own while the urban areas are showing large population increases.

The terrain is no handicap to the transportation network system. Indianapolis is the dominant urban city in central Indiana. Four major railroads service Indianapolis: The New York Central, Pennsylvania, Illinois Central, and the Baltimore and Ohio.[6] The highway system is excellent. Four interstate routes pass through Indianapolis. The interstate routes are 65, 69, 70, and 74. There are six major highways that crisscross Indianapolis.

In the White River Basin, only 5 percent of total employment is in agricultural pursuits. Less than 2,000 acres were under irrigation in 1959 out of 6½ million.[7] Approximately 40 percent of the value of farm products is from field crops, 50 percent from livestock products, and the remainder from dairy and poultry products.

In 1960, the 3 counties making up the study area in the Eel River Basin had 14 percent of the total employment engaged in agricultural pursuits. The 4 counties in the East Fork study area had 12 percent and the 9 counties in the White River Basin proper had only 3 percent.

Agriculture continues to be an important industry in Indiana but it will require less employment. The total value of farm products is increasing in Indiana. While the value of field crops declined from 1954 to 1959, value of livestock and poultry increased. In 1959, the total value of farm products sold approached one billion dollars. It is this farm base that will provide increased farm income in the future.

The total value of mineral production has remained fairly constant for the past 10 years. In the study area, only 3 counties employ more than 100 persons in mining: Clay, 200; Marion, 200; and Owen, 100. Clay and Owen are in the coal mining area. The mining employment in Marion County is sand, gravel, and limestone.[8]

In the Eel River study area, there is one large International Business Machines Corporation plant employing over 1,000 employees. The IBM plant engages in die-cutting purchased paper and paperboard. This plant is not a heavy water user due to the fact that it does not manufacture the paper. There is a brick and tile plant with over 500 employees in Clay County. Stone and clay products plants are the most numerous for the Eel study area. (See Table VI-1 for the other plant sizes.)

The East Fork study area has a heavy concentration of plants in primary metals, fabricated metals, non-electrical machinery, and transportation equipment. (See Table VI-2 for plant size.)

A major manufacturing center is Indianapolis. Table VI-3 shows the diversity and depth of the manufacturing categories in the counties around the urban areas of Indianapolis, Anderson, and Muncie. There are 28 plants with over 1,000 employees. The main categories of plants in the urbanized areas of Anderson, Indianapolis, and Muncie are food and kindred products, transportation equipment, fabricated metals, machinery (both electrical and nonelectrical), primary metals, plastics, and chemicals.[9] It is this industrial complex in central Indiana that provides the base for future economic growth and expansion of the urban areas.

Future

The projected prosperity of the study areas depends upon the continued expansion of the diverse industrial base concentrated along the White River. This industrial area encompasses the three major urban areas of Anderson, Indianapolis, and Muncie.

The indices of output projections (see Tables VI-4, VI-5, and VI-6) were compiled from the employment data supplied by the Louisville District Office Corps of Engineers and productivity per employee data for the years 1976 and 1985 from the National Planning Association. Extrapolations of the indices were made from 1980 to 2020.

Urban area projections are based upon historical relationships between the urban areas and the county within which the area is contained. These projections, as well as county projections, are shown in Table VI-7. Total study area population is projected to increase by 88 percent from 1,340,000 in 1960 to 2,514,000 by 2020.

Projected growth rates by subarea show the Eel River subarea increasing its population by slightly more than 50 percent from 1960 to 2020, with an accompanying slight percentage increase in urbanization. In the East Fork White River subarea, population is expected to increase by 87 percent between 1960 and 2020. In the White River subarea, population is expected to increase by 90 percent between 1960 and 2020, with the urbanized area of Indianapolis increasing its percentage of the subarea population only slightly.

The Federal Power Commission has projected electric power capacity to increase 183 percent from 1963 to 1980 in the White River Basin. Most of the increase will be used by the industrial complex of Anderson, Indianapolis, and Muncie.

The projections in this section have been used for calculating future water supply and water quality needs in subsequent sections of this report.

VII. WATER REQUIREMENTS-MUNICIPAL AND INDUSTRIAL

Present Water Use

Table VII-1 (see Appendix) lists the municipal supplies for the three subareas comprising the study area. A summarization of these data is shown below.

Subarea	Population Served	Total Municipal Use mgd	Ground Water Use mgd	Surface Water Use mgd	Average Demand gpcd
Eel River	29,000	2.9	2.6	0.3	100
East Fork	76,000	7.8	7.7	0.1	103
White River	873,000	107.6	21.6	86.0	123
Totals	978,000	118.3	31.9	86.4	121

Average water use by municipality varies from 30 to 162 gallons per capita per day (gpcd). The average of 121 gpcd is strongly influenced by the consumption from the Indianapolis Water Company system which serves 615,000 people and has an average use of 123 gpcd. The communities of less than 5,000 population have an average use of 77 gpcd. These average use figures include some associated business and commercial use and an estimated 32 mgd industrial water use from public water supplies. Most of this indicated industrial water use is in the Marion County (Indianapolis) area. By subtracting the above estimated industrial water use, an average water use of 88 gpcd is obtained solely for domestic, commercial, and general public use.

Total estimated industrial water use in the study area is shown in the following tabulation. Of this total, 32 mgd is estimated to originate from public water supply sources and 575 mgd from self-supplied industrial water sources.

Subarea	Total Estimated Industrial Water Use for 1963 in mgd
Eel River	0.6
East Fork	8.0
White River	
Thermal Power Plant Cooling Water	506.0
Other Industrial Uses	92.0
Totals	607.0

In the Eel River subarea only small quantities of water are utilized by industry. Some coal mining companies utilize ground water in their operations. The two industrial firms in Greencastle that employ the largest number of employees utilize water from the municipal system.

The major industrial water use locations in the East Fork White River subarea are at New Castle, Shelbyville, and Carthage. Self-supplied surface water is the dominant source of industrial supply. The greatest amount of industrial water use is by the pulp and paper, canning, primary metals, and pharmaceutical industries.

In the White River Basin subarea the greatest use of water by industry, exclusive of cooling water for thermal power plants, is in Indianapolis with an estimated 76 mgd total from public and self-supplied sources. That obtained from public supplies originates mostly from surface water sources, while that which is self-supplied is mostly from wells or Ranney collectors along White River. Industries utilizing large quantities of water in the Indianapolis area include meat packing, pharmaceuticals, paper manufacturing, primary metals, fabricated metals, and machinery.

Other areas of considerable industrial water use in the White River subarea are at Anderson and Muncie. Electrical machinery, meat packing, batteries, and fabricated metals are major industries in these communities which are within 19 miles of each other. Estimated industrial water use in this area is 16 mgd, of which about one-half is estimated to come from municipal sources and half from self-supplied sources.

Water use for irrigation purposes is limited in the study area as a whole. A limited amount of water is used for truck crops in Marion County. No estimate of actual use could be obtained.

The U. S. Economic Research Service of the U. S. Department of Agriculture submitted a preliminary report to the Louisville District Corps of Engineers dated June 25, 1965. This report stated that there is presently no irrigation in the Big Walnut Creek Reservoir area. There are about 1,000 acres presently irrigated in the Big Blue Reservoir area from above the Shelby-Hancock County line to the confluence of

Driftwood and Flatrock Rivers near Columbus. In the area from the Downeyville damsite to the confluence of Clifty Creek and East Fork of the White River, about 900 acres of land are now irrigated. About half of this acreage is irrigated from the river and half from wells.

Existing Sources of Supply-Surface and Ground Water

Quantity

In the Eel River Basin the four largest communities (Greencastle, Brazil, Jasonville, Clay City), serving about 24,700 persons, are obtaining their water supplies from well fields in glacial outwash deposits paralleling or near to the Eel River or Big Walnut Creek. The largest developed well is 1,000 gpm at Greencastle. Brazil and Jasonville abandoned wells closer to the community and went some miles to reach this relatively good aquifer. Smaller communities, serving about 2,800 persons in this basin, utilize wells in aquifers with less potential than the outwash deposits.

In addition to the ground water resources, there exists a relatively untouched surface water potential from the Eel River and its tributaries. Minimum daily flows are 1.4 cfs at Reelsville on Big Walnut Creek (drainage area 338 square miles) during a period of record from 1949 to 1964, and 11 cfs at Bowling Green on Eel River (drainage area 844 square miles) during a period of record from 1931 to 1964.

The Putnamville State Farm, a correctional institution of the State of Indiana, has a low head impoundment on Deer Creek. During drought years Deer Creek has flows insufficient to meet the needs of the

institution. Wells have been drilled in the Deer Creek valley floor and are pumped during emergencies. The problem of a reliable water supply has not been solved, and several methods of obtaining more water have been investigated including storage reservoirs in the Deer Creek Basin and a well field in the Big Walnut Creek valley which is approximately four miles away.

In the East Fork of White River subarea, the total existing municipal water supply is from ground water sources except for 0.08 mgd at Princes Lake. Estimates of potential yields from ground water sources are unavailable. However, considerable undeveloped potential exists and, particularly in areas near Big Blue River, significant quantities of ground water can be developed. Surface water has not been developed as a significant source of supply because of this general availability of ground water. Base flows are relatively good on Big Blue and Driftwood Rivers. The minimum daily flow of the Big Blue River at Shelbyville (drainage area 425 square miles) was 32 cfs during the period of record from 1944 to 1964. On Sugar Creek near Edinburg (drainage area 462 square miles), the minimum daily flow from 1943 to 1964 was 9.2 cfs. On Flatrock River at St. Paul (drainage area 298 square miles), the minimum daily flow from 1931 to 1964 was 0.6 cfs.

In the White River area, Muncie's present sources of supply are the White River and Buck Creek. In addition, a 21,500 acre-foot impoundment has been constructed on Prairie Creek, an upstream tributary of White River. This system provides an estimated firm yield of 13.8 mgd.

The city also has eleven wells which are not normally used at this time but are available for emergencies. The estimated firm yield of these wells is 3 mgd, providing a total present installed system capability of 16.8 mgd.

The city of Anderson utilizes wells as a primary source of supply. A Ranney well collection system near the mouth of Kilbuck Creek serves as a major source of supply. This system is recharged to a considerable extent from the streamflow. A low head impoundment on White River is used during times when the well system is incapable of meeting the needs. This is usually during periods of low streamflow and high demands. The firm capabilities of the present supply sources are 7.5 mgd from surface sources and 10.5 mgd from ground water for a total of 18 mgd.

The privately owned Indianapolis Water Company utilizes the White River and Fall Creek as its major sources of supply. Impoundments on Cicero Creek, an upstream tributary of White River, and on Fall Creek supplement the natural streamflow to provide a firm yield from surface sources of 95 mgd. Forty wells are available but are pumped only occasionally. The water company does not presently pump these wells for extended periods and considers their prime function that of providing for flexibility of operation and as an emergency source rather than as an addition to their firm supply.

The town of Speedway, in 1965, went to Eagle Creek as its major source of water supply. The town has retained its six wells, which have a firm yeild of 3.0 mgd, to supplement the creek flow when needed.

The Eagle Creek Reservoir, now under construction, will have storage for water supply. The reservoir has a firm yield of about 16 mgd. It is anticipated that both the city of Indianapolis and the town of Speedway will purchase water from this source.

The other public water systems in the White River subarea utilize wells for their sources of water supply as do most self-supplied industries in the area. These sources of supply are generally adequate for short-term future needs. In many instances, inadequate testing and evaluation of ground water potential result in an inability to assess present sources of supply. Generally for moderate and small-sized communities, obtaining adequate quantities of water is largely a matter of well field expansion and exploration to determine the most favorable areas for ground water development.

Quality

Tables III-5 and III-8 show the water quality generally available to the two major surface water users (Indianapolis and Muncie) in the study area. The hardness generally ranges from 200 to 370 mg/l and the alkalinity from 150 to 300 mg/l. These levels are generally typical of the surface water in the area which can be typified as hard and having a high alkalinity.

Above points of major organic pollution, the surface water is of a quality amenable to normal treatment consisting of coagulation, sedimentation, filtration, and chlorination.

Ground water quality is shown in Table V-1. Hardness ranges from 200 to 475 mg/l and alkalinity from 240 to 390 mg/l. This can be characterized as very hard with a high alkalinity. Many of these wells are at a relatively shallow depth and base streamflow results from ground water contribution, so, as would be expected, these are similar quality characteristics to that for the surface water in the area. Iron is a problem from some well supplies and iron removal is a common practice. In addition, softening is practiced at some of the treatment plants.

Future Municipal and Industrial Water Requirements

Current water use levels are discussed at the beginning of this chapter. The current use was evaluated to determine as nearly as possible the amount utilized by industry and the amount utilized for domestic, commercial, and general public use. This evaluation was used as a base from which projections for future water use were made. The industrial water use was projected on the basis of economic output projections in Chapter VI with an assumed increasing efficiency in water use per unit of product. Domestic, commercial, and general public use was projected on the basis of a continuing trend of increased per capita use. The assumed values are shown on the following page for the study area.

Year	Gallons per Capita per Day
1963	88
1980	95
2020	120

Based on the above described methods, total projected water use by subarea was obtained and is summarized below.

Study Area	Water Use in mgd		
	1963	1980	2020
Eel River Subarea			
Industrial	0.6	1.3	3.5
Dom., Com., & Gen'l.	2.3	3.5	6.8
Total	2.9	4.8	10.3
East Fork Subarea			
Industrial	8.1	12.0	25.0
Dom., Com., & Gen'l.	6.3	8.8	21.0
Total	14.4	20.8	46.0
White River Subarea			
Industrial	92.0	134.0	264.0
Dom., Com., & Gen'l.	78.0	105.0	202.0
Total	170.0	239.0	466.0
Study Area Totals	187.0	265.0	522.0

These projected water use figures do not include cooling water needs for thermal electric power generation. At present, an estimated 506 mgd is used for this purpose. This is the total use at four generating plants on White River. During low flow periods a successive reuse of the streamflow for cooling and other purposes results. The A. D. Little "Projective Economic Study of the Ohio River Basin"[4] relates future power production location to areas with coal resources. Significant coal resources exist in an area generally west and southwest of the study

area. It is therefore concluded that the future power needs of the study area will for the most part be generated outside the area and cooling water needs within the study area will not be a controlling water supply factor.

In the Eel River subarea, the present water needs are being met almost exclusively by ground water. The outwash sand and gravel deposits along Big Walnut Creek, in the Greencastle area and below, and along the Eel River should be capable of significantly increased levels of development. In addition, natural streamflow could be used to supplement ground water if necessary to meet the projected water supply need of 10.3 mgd by the year 2020. In the upstream areas, the communities all have less than 1,000 population and use ground water from sources with less apparent potential than the downstream outwash deposits. It is believed the future needs of these communities can be met by expansion of existing well fields and, should the need develop, by exploration to develop additional or better yielding nearby ground water sources. The northeastern portion of this subarea is close enough to the Indianapolis metropolitan area (22 to 30 miles) to support future major bedroom or commuter communities. This possibility is enhanced by two interstate highways, one of which will traverse this area and one which will be near this area. Locations of such possible communities cannot be determined and possible storage needs for such a development cannot be logically evaluated. Water supply for such a community might very

possibly be from expansion of the Indianapolis Water Company's service area or by a water district purchasing water from an existing supply. Needs for the Indianapolis metropolitan area are included in the White River subarea totals and, to the extent that this metropolitan area may spread into the upper Eel River Basin, water use therefrom is included in the White River subarea totals.

The Putnamville State Farm was estimated to have a 1980 water requirement of 0.68 mgd in a 1956 investigation by the Indiana Flood Control and Water Resources Commission.[10] This would require an additional 0.48 mgd of water supply to supplement its present estimated firm supply of 0.2 mgd. Projections beyond the year 1980 are unavailable and normal projective techniques are not applicable to this type of institution. Assuming the institution population paralleled the State population projections[11] and that the 1980 projected water use level of 290 gpcd for the institution continued, a projected water use by 2020 of 1.2 mgd is obtained or 1.0 mgd more than the present firm yield. Based on this projected need, there is a potential need for storage in Big Walnut Creek Reservoir to meet water supply needs of 1.0 mgd in the Eel River subarea.

The East Fork subarea obtains virtually all of its municipal supply from ground water sources. These existing sources along with the natural flow of the streams are expected to be sufficient to meet the projected water supply needs in all except upper headwater areas. Should existing ground water sources of supply prove inadequate for future needs,

supplementation with the natural flow of Big Blue River will be sufficient to meet needs at Franklin, Shelbyville, Rushville, Edinburg, New Whiteland, Whiteland, Knightstown, Carthage, Morristown, and Greenfield, and supplementation with natural flow in Flatrock River will be sufficient to meet needs at St. Paul. For some of these communities, pipelines would have to be constructed to intake points on the Big Blue River in the stream reach from Knightstown to Edinburg. The upstream communities of New Castle, Lewisville, Shirley, and Spiceland are not as favorably situated to allow potential use of natural flow to supplement ground water development. The latter three communities, however, are all small enough (less than 1,100 population) that nearby ground water development should be capable of meeting future needs. At New Castle present municipal and self-supplied industrial water use is estimated to be 4.2 mgd and is expected to increase to 7 mgd by 1980 and 16 mgd by the year 2020. While existing ground water potential cannot be accurately estimated from existing information, a previous report on ground water in the area concluded that the community would very possibly have to eventually use surface sources of supply.[12] Based on past and projected growth, it is concluded that these sources must be utilized some time during the 1980 to 2020 period. If available ground water sources can be economically developed to a level of 7 mgd, 9 mgd of surface water supply will have to be provided to meet 2020 needs, with a first need occurring in the year 1980.

Reservoir storage is capable of satisfying a water supply need established for Greensburg, Indiana, in a previously published report entitled, "Water Resources Study, Clifty Creek Reservoir, Wabash River Basin, Indiana," by the U. S. Department of Health, Education, and Welfare, January 1964. Greensburg's projected water needs are for an additional 2.4 mgd by the year 2020, with the year 1982 the estimated time of first need. This need would most logically be met by storage for water supply in Downeyville Reservoir. Greensburg presently has a low head impoundment on Flatrock River approximately one mile below the location selected for the Downeyville damsite.

The White River subarea is expected to need about 466 mgd to satisfy its municipal and industrial water supply needs for the year 2020. Approximately 86 mgd of this is projected for the upper portion of the subarea centering around Muncie and Anderson and including the counties of Madison, Delaware, Randolph, and part of Tipton County. The other 380 mgd is projected for the area centering on Indianapolis and including Marion, Hamilton, Hendricks, Morgan, and portions of Boone and Johnson Counties. Two portions of the subarea are tabulated below.

Muncie-Anderson Area
(Madison, Delaware, Randolph, and Tipton Counties)

	1980 (mgd)	2020 (mgd)
Projected Municipal and Industrial Water Supply Need	48	86
Existing Dependable Draft (Ground Water)	24	24
Existing Flow plus Storage	23	23
Totals	47	47

Muncie-Anderson Area (Cont'd)
(Madison, Delaware, Randolph, and Tipton Counties)

	1980 (mgd)	2020 (mgd)
Additional Municipal and Industrial Need		
Utilizing White River Flow at Anderson	1	39
Not Utilizing White River Flow at Anderson	8.5	46.5

Even though the above area tabulation shows 23 mgd from streamflow plus storage, 7.5 mgd of this indicated existing water supply is from the White River and a low head impoundment on White River at Anderson. This is a secondary source of supply for Anderson and is only 17 stream miles below the discharge of municipal and industrial wastes from Muncie. Because of limited base flow, the nearness to Muncie and the high level of industrialization, much of which is in metals where plating wastes present a potential hazard, the White River at Anderson is a dubious source of future water supply.

Indianapolis Area
(Marion, Hamilton, Hendricks, Morgan, and portions of Boone and Johnson Counties)

	1980 (mgd)	2020 (mgd)
Projected Municipal and Industrial Water Supply Need	191	380
Existing Flow plus Storage (White River, Fall Creek)	95	95
Existing Ground Water Development	70	70
Augmented Streamflow from Upper Basin Water Supply Development	--	30
Total Available Supply	165	195
Additional Water Supply Required	26	185

Some of the projected need for additional water supply can be expected to result from increased development of ground water by industries and the 22 public water systems presently utilizing ground water sources of supply. The Indianapolis Water Company has further development of surface water from both upstream and downstream sources included in its long-range plans. This company foresees a possible need for an additional capability (in excess of present firm sources of supply) of 25 mgd by 1980 and 100 mgd by the year 2010.

Of the total estimated additional 185 mgd water supply needed by the year 2020, it is estimated that from 100 to 150 mgd will be developed from surface water sources and the remainder from ground water, depending on the relative economics and availability of supply from the two sources. It is therefore concluded that a need for reservoir storage to yield a minimum of 100 mgd is needed to satisfy municipal and industrial water requirements in Indianapolis and the surrounding area by the year 2020. The required storage should be provided, to the extent consistent with optimum use of water resources, in the Big Walnut and Big Blue Reservoirs.

The U. S. Economic Research Service of the U. S. Department of Agriculture in a report dated June 25, 1965, stated that: "...Preliminary analysis of the supply of and demand for agricultural products in the Wabash Basin indicates that there will not be a significant shortage of land and water resources needed for food and fibre production in 1980

and 2010. Therefore, further expansion of irrigation and other forms of resource development would not be necessary to meet production requirements. Increases in irrigation can be expected, however, if per unit costs of production can be decreased by its use. ...In general, the volume of water used for irrigation is likely to remain small relative to the amounts used for other purposes."

The needs for storage for water supply indicated in this report are in addition to that which may be required for irrigation as indicated in the previous paragraph.

The following tabulation briefly summarizes the municipal and industrial water supply needs which have been identified in the previous text. Excluded from this listing are areas where expected economic development of ground water or where ground water plus base streamflow will be sufficient to meet future needs.

Summary of Water Needs (in mgd)
Not Satisfied by Present Firm Sources of Surface Supply or by Expected Development Capabilities of Ground Water

	1980			2020		
	Water Supply Requirements	*Firm Supply	Additional Need	Water Supply Requirements	*Firm Supply	Additional Need
Putnamville State Farm	0.7	0.2	0.5	1.2	0.2	1.0
New Castle Area	7.0	7.0	---	16.0	7.0	9.0
Greensburg***	2.8	3.0	---	5.4	3.0	2.4

Summary of Water Needs (in mgd)
Not Satisfied by Present Firm Sources of Surface Supply or by Expected Development Capabilities of Ground Water (Cont'd)

	1980			2020		
	Water Supply Requirements	*Firm Supply	Additional Need	Water Supply Requirements	*Firm Supply	Additional Need
Muncie-Anderson Area	48.0	39.5	8.5	86.0	39.5	46.5
Indianapolis Area	191.0	165.0	26.0	380.0	195.0	185.0**

*Firm supply is present dependable surface water supply and ground water development. For Indianapolis area augmented streamflow from Muncie-Anderson area is considered part of 2020 dependable surface supply.

**An estimated 100-150 mgd is expected to be required from surface water sources with the remainder from further development of ground water.

***Figures for Greensburg are extrapolated from Clifty Creek Report.

VIII. WATER QUALITY CONTROL

The control of water quality centers around economic and public health aspects of instream and withdrawal uses. Benefits accrue from the possible use of water for recreational activities, public and industrial water supply, and esthetic enjoyment. Economic benefit is reduced if water quality is such as to restrict these uses, make treatment for beneficial uses more costly, result in the necessity of substituting more remote and therefore possibly more expensive water based recreational activities, result in corrosion or scaling of watercraft, domestic, navigation, and industrial equipment and facilities. Economic benefit is also lost if obnoxious fumes result in damage to painted surfaces, loss of esthetic enjoyment and reduced land values.

Municipal and Industrial Pollution

Table VIII-1 (see Appendix) shows the present status of municipal waste facilities in the study area. Generally for communities greater than 1,500 in population, secondary treatment has been provided. The following is a summarization of data by subarea. Unless information was available to indicate a different percentage removal of 5-day biochemical oxygen demand (B.O.D.), this report is based on the usual observation that secondary treatment provides 85 percent B.O.D. removal and primary treatment 30 percent B.O.D. removal.

Treatment Facilities	Population Served	Population Equivalent Based on B.O.D.	
		Raw Wastes	Wastes Discharged to Streams
Eel River Subarea			
Secondary Treatment	21,800	21,800	3,300
Primary Treatment	----	----	----
Sewered with no Treatment	1,400	1,400	1,400
Total	23,200	23,200	4,700
East Fork White River Subarea			
Secondary Treatment	68,900	63,400	9,800
Primary Treatment	----	----	----
Sewered with no Treatment	5,400	5,400	5,400
Total	74,300	68,800	15,200
White River Subarea			
Secondary Treatment	699,400	1,584,000	238,300
Primary Treatment	11,200	10,900	7,800
Sewered with no Treatment	24,800	24,800	24,800
Total	735,400	1,619,700	270,900
Study Area Totals	833,000	1,712,000	291,000

Table VIII-2 (see Appendix) shows a tabulation of industrial waste treatment facilities with separate discharges (not discharging to public sewer systems). As a general rule, industries with discharges containing high levels of B.O.D. are connected to city sewers. The total population equivalent based on B.O.D. is estimated to be 41,100.

As noted in Chapter V, seriously degraded conditions exist on the White River below Muncie and below Indianapolis. During drought periods there is less dilution water in the White River than the discharge volume from the Indianapolis sewage treatment plant. The same is true below Muncie. Zero dissolved oxygen levels were observed on occasion in these stream reaches during a 1965 sampling program by the Evansville Field Station of the Ohio River Basin Comprehensive Project. Water quality is generally good below the proposed Big Walnut, Big Blue, and Downeyville damsites.

In addition to waste loadings from the municipal and industrial sources previously described, pollutants enter streams from agricultural and other sources. During periods of surface runoff, pollution from insecticides, pesticides, fertilizers, and from barnyard and pasture runoff in rural areas would occur. Also, urban street washings and storm water flow would contribute significant waste loadings to streams. The net loading from such sources would be difficult to measure and estimate; however, solids that might accumulate in the stream's channel would contribute to sludge deposits. Nutrients derived from these and other sources would contribute to algal growths.

Pollution from the above sources as well as from treated municipal and industrial wastes contains biodegradable organic materials. Stabilization of these organic materials results in a demand on the dissolved oxygen in the stream. If the quantities of these materials exceed the assimilative capacity of the stream, lowered dissolved oxygen

levels will result. Lowering of D.O. levels below requirements for the fish life will result in fish kills or, in less severe cases, will result in environmental conditions unfavorable for growth and/or reproduction. A stream will eventually recover from such a condition if no additional waste loadings are introduced and sufficient time elapses for natural atmospheric reaeration to replace the oxygen demanded to stabilize the organic wastes.

Some pollutants are nondegradable or very slowly degradable in nature. In this category are most strictly chemical pollutants such as chlorides, sulfates, acidity, and excess alkalinity. Pesticides and herbicides are not normally considered subject to immediate degradation on being introduced into stream systems. Inflow of water containing a lower concentration of non-degradable pollutants results in a dilution effect, and the pollutional characteristic is partially or possibly completely eliminated.

Water Quality Criteria

The quality of water determines the uses that can be made of it and, unless proper quality is maintained, possible economic benefits of its use will be lost and public health endangered. Withdrawal and instream uses determine the water quality objectives applicable to a stream. The objectives used in evaluating quality conditions in the study area have been based on use of Big Walnut Creek, Eel River, and Big Blue River as

a potential source of raw water supply for the communities located nearby, general recreational use including fishing, and on preventing loss of esthetic environment from degraded streamflow conditions.

The Manual of Recommended Water Sanitation Practice of the Public Health Service has been used as a guide to acceptable raw water quality and is used here to select objectives for the maximum coliform concentrations in the raw water at water treatment plants' intakes. Coliform densities in excess of 5,000 per 100 ml in 20 percent of the samples in any month or 20,000 per 100 ml in more than 5 percent in any month should be avoided, even with coagulation, filtration, and post chlorination. Chlorination of the effluent from waste treatment plants is considered a more economical control method than regulation of streamflow. However, it should be recognized that bacteria in uncollectable wastes such as emanate from storm water overflows or street washings are not affected by chlorination of waste treatment plant effluents.

Raw waters, in addition to meeting bacterial requirements, should be free of excessive toxic, taste producing, or otherwise harmful substances. Raw waters should contain no organisms not readily or completely removable by ordinary water treatment and should be free of excessive amounts of acid, microscopic organisms, and organic matter causing any interference with normal operation and efficiency of water treatment processes.

The 1962 Public Health Service Drinking Water Standards, which applies to finished drinking water on interstate carriers, limits total

dissolved solids to 500 mg/l where other more suitable supplies are or can be made available. This same standard has a similar recommended limit of 250 mg/l for both chlorides and sulfates.

The Indiana Stream Pollution Control Board has by Regulation SPC 1 established the following standard for receiving waters, "...Generally the oxygen content of the receiving water, after being mixed with and affected by the waste, shall be no less than 50 percent saturation. A lower concentration will be tolerated temporarily, but only so long as it is not injurious to aquatic life, and in no case shall it fall below 25 percent saturation." At present the flow of the White River below Muncie and Indianapolis is insufficient to allow maintenance of this standard even with adequate treatment of wastes.

A water quality goal was established after considering a number of water quality indicators. It was found that maintaining a water quality goal of 5 mg/l of dissolved oxygen resulted in levels of total dissolved solids, chlorides, and sulfates within the recommended limits previously referred to in the 1962 Public Health Service Drinking Water Standards.

The water quality goal of 5 mg/l of dissolved oxygen was selected on the basis of anticipated municipal and industrial water supply, aquatic life, esthetics, and recreational use. In selecting dissolved oxygen goals for streams to protect aquatic life, mere survival is not enough. The minimum level selected should be suitable for the continuance of satisfactory fish life and fish food organisms. On the basis of studies by the Public Health Service on Lytle Creek in the

Cincinnati area, it was concluded that for a well-rounded, warm-water fish population dissolved oxygen concentrations should not be below 5 mg/l for more than 8 hours of any 24-hour period and at no time should it be below 3 mg/l. Since the study area is within about 150 miles geographically of Lytle Creek and similar species of fish abound in both streams, the above statement of necessary oxygen concentrations was the basis of the water quality goal for this study.

Flow Regulation

In the future, increased waste discharges in the Eel River and Big Blue River Basins will, even after adequate treatment, result in reduced water quality during low flow periods. In the Sugar Creek Basin (a tributary of East Fork White River, see Figure III), which drains a portion of eastern Marion County as well as western Shelby and Hancock Counties, expansion of the urban Indianapolis area will probably result in major increases in population and in wastes discharged. It is expected that with increased population a sewage treatment plant will be built to serve this area. Presently, lift stations are utilized to pump sewage for a limited population in eastern Marion County into the Indianapolis sewerage system. After treatment, this sewage is discharged to the White River Basin. Below Indianapolis and Muncie-Anderson in the White River Basin, and below New Castle in the Big Blue Basin, water quality is degraded below the established goal during low flow periods. For each of these areas, needs for water quality control exist which could be satisfied by reservoir storage.

In addition to the above needs, a January 1964 study of the proposed Clifty Creek Reservoir[13] established water quality control needs on the East Fork White River below Columbus. These flow needs were established as from 48 to 55 mgd in 1976 and from 103 to 113 mgd in 2010. For the purposes of this report, the higher 1976 value of 55 mgd was accepted for the expected 1980 need and the higher 2010 value of 113 mgd was accepted for the expected 2020 need.

The aforementioned critical stream reaches are tabulated below with flow needs for water quality control. These flow needs are based on adequate control of wastes at the source and adequate treatment, which is defined as conventional secondary treatment providing 85 percent removal of B.O.D. If quality is maintained throughout the critical reaches, quality is expected to be insured in the stream as a whole.

Critical Reaches by Stream System	Design Flow* (mgd)	Summer Flow Needed to Receive Treated Wastes	
		1980 (mgd)	2020 (mgd)
Big Walnut Creek-Eel River System			
(1) Big Walnut Creek below Greencastle	<2	8	12
Upper Tributaries East Fork White River System			
(1) Big Blue River below New Castle	<12	14	25
(2) Big Blue River below Shelbyville	24	24	70
(3) East Fork White River below Columbus (based on Clifty Creek Reservoir report)	49.5	55	113
White River-Main Stem			
(1) White River below Muncie-Anderson	<39	120	195
(2) White River below Indianapolis	80	540	975

*The design flow is defined as the minimum 7 consecutive-day mean flow with an expected 10-year recurrence interval.

Needs for other months of the year are expected to be the following percentages of the summer flow needs: May and October, 80 percent; April and November, 70 percent; December, January, February, and March, 50 percent.

The indicated flow needs should not be interpreted as an operating schedule. Each period of deficient streamflow would be characterized by different temperature levels. The temperature and waste loadings that materialize would affect the actual needed releases during the period of drought.

Of previously tabulated critical reaches, a complete evaluation was made for Big Walnut Creek below Greencastle, Big Blue River below Shelbyville, and White River below Muncie-Anderson. Needs as previously outlined below Columbus in the Clifty Creek report[13] were not specifically re-evaluated but are shown in this report for a more complete understanding of total area needs. For the critical stream reach below New Castle, storage from the subject reservoirs was not seriously considered. The proposed Big Blue Reservoir is about 25 miles downstream and pumping to below New Castle would not involve a significant demand on storage since the pumped flow would be returned undiminished except for perhaps a small loss to evaporation and/or recharge to alluvium in the stream channel. A "Watershed Work Plan" for a P.L. 566 project in the upper headwater areas of the Big Blue River Basin has been submitted to a Congressional Committee in Washington. Two structures in the work plan include storage for water quality control. Under present legislation the cost of providing such storage cannot be at Federal expense.

Because of a lack of sufficient storage in potential reservoir sites above Indianapolis, water quality control for the White River below Indianapolis cannot be attained by this method alone, even with adequate treatment of wastes. Until such a time as a complete field study to determine stream characteristics is completed and a thorough evaluation of alternates is completed, a definitive recommendation cannot be made. However, reservoir storage from the proposed structures can be a partial solution. In the benefits section, cost of storage in alternate reservoirs upstream from Indianapolis is used to place a value on the contribution of this partial solution.

For those needs that can be evaluated at this time, a draft-on-storage has been determined by comparing water supply and waste return flow conditions expected in 1980 and 2020 with streamflows in each year of the past record. The results of these calculations were arrayed in order of magnitude and are presented graphically in the Appendix. The results of these analyses are tabulated below. These represent draft-on-storage at the point of need with no allowance for evaporation or transmission losses. The values given should maintain water quality in nine out of ten years. For needs for other recurrence intervals, see Figures VI and VII in the Appendix.

	Draft-on-Storage in Acre-Feet	
	1980	2020
Big Walnut Creek below Greencastle	600	1,400
Big Blue River below Shelbyville	0	12,000
White River below Muncie-Anderson	34,000	80,000
East Fork White River below Columbus	0	11,000

The expected adequately treated waste flows to Flatrock River below Downeyville Reservoir can be adequately assimilated by natural flows in an expected seven consecutive day once in ten year mean low flow condition. Therefore, no storage is requested in Downeyville Reservoir for water quality control in Flatrock River. The Bureau of Sport Fisheries and Wildlife, Lebanon, Ohio, in a report has requested a minimum April to September flow of 50 cfs below the proposed reservoir to maintain fish habitat.

The proposed reservoirs are expected to be subject to the detrimental influence on water quality of thermal density stratification. Under such conditions the epilimnion of the impoundment remains aerobic due to wind mixing and contact with the atmosphere, but the water in the hypolimnion is trapped below the thermocline and is prevented from undergoing atmospheric reaeration. The oxygen demand in these waters consumes the original dissolved oxygen content. After anaerobic conditions have developed, other detrimental reactions take place; iron, manganese, and color may go into solution and the pH may decline. Release of this water through outlet works could cause harmful downstream effects. Design of the reservoir should include features to avoid these difficulties. Multiple-level outlets are recommended to allow the selection of the most suitable quality of water. Outlets should be provided with a vertical spacing of approximately 10 feet in the conservation and seasonal pools. Installation of recording instruments to indicate water quality at the several levels would facilitate operation of the flow release structures.

Consideration of anticipated flow from unregulated areas, such as is provided by the Weather Bureau River Forecast Section and frequent observation of downstream conditions including establishment of a water quality monitoring system, will allow determination of the required quantity and quality of releases to maintain water quality objectives.

The above recommendations for flow needs and draft-on-storage are based on limited data. A more detailed analysis will be possible when information from the Ohio River Basin Comprehensive Project by the Federal Water Pollution Control Administration is available.

IX. BENEFITS

Water Supply Benefits

As previously outlined in Chapter VII, needs for municipal and industrial water supply that could be satisfied by reservoir storage exist in the study area. The areas of need were determined to be in the Eel River subarea at Putnamville State Farm, in the East Fork White River subarea at New Castle and at Greensburg, and in the White River subarea in two multi-county areas, one centering on Muncie and Anderson and one centering on Indianapolis.

For the New Castle area and the Muncie-Anderson area, estimated costs of pumping and amortization of transmission facilities from the reservoirs under study exceed the costs of possible single-purpose reservoir development near the points of need. Therefore, there is no value for storage in the Big Walnut, Big Blue, or Downeyville Reservoirs to satisfy water supply needs in the New Castle or Muncie-Anderson areas.

For the Putnamville State Farm, an additional 1.0 mgd of water supply is expected to be required to meet needs for the year 2020. This need could be satisfied by utilizing base flow plus storage releases at a point directly below Big Walnut Creek Dam and utilizing a 2-mile pipeline to transport the water to an upstream tributary of the Farm's Deer Creek water supply source. Alternates to providing for the need in the above manner include an impoundment upstream in the Deer Creek watershed or a pipeline to the Big Walnut Creek valley about four miles west. At this point, either wells in the alluvium or use of base streamflow might serve

to satisfy the need. The latter was considered the most economical alternate. Based largely on the difference in pipeline costs, the annual benefit of storage in Big Walnut Creek Reservoir for satisfying this need is estimated at $3,500 per year.

For Greensburg, the municipal and industrial water supply need for 2020 is projected to be 5.4 mgd. A total of 3.0 mgd is available from the present ground water development and the reliable flow from Flatrock River as augmented by storage from a low head dam. The additional 2.4 mgd need could be supplied from storage releases from the proposed Downeyville Reservoir, which would be located one mile upstream from Greensburg's present low head dam. The benefit of providing for this need based on the cost of the most economical alternate, which is a single-purpose reservoir, on a small stream near Greensburg with an estimated first cost of $140,000 is $6,500 per year. This benefit is discounted from 1982, the time of estimated first need, to 1970 and includes operation and maintenance costs.

For the Indianapolis area, a need for 185.0 mgd of additional water supply by the year 2020 is projected. Some of this need is expected to be satisfied from more extensive ground water development. However, at least 100.0 mgd is expected to be developed from surface water supplies. Big Walnut Creek Reservoir is capable of satisfying approximately 78.0 mgd of this projected need from conservation storage not allotted to water quality control needs in the Eel River Basin. By developing facilities

to provide 78.0 mgd of water supply to the Indianapolis area, the benefit of storage in Big Walnut Creek Reservoir is estimated at $575,000 per year. This is based on the most economical alternate of providing single-purpose storage in upstream portions of the White River Basin.

The computation of annual benefit includes yearly operation and maintenance costs and amortization of investment at the Federal interest rate of 3 1/8 percent. Operation costs included pumping costs for the pipeline to Big Walnut Creek Reservoir and expected savings in treatment costs from use of a better quality water from Big Walnut Creek Reservoir. Determinations of treatment cost savings were based on present costs reported by the Indianapolis Water Company of $25.62 per MG (million gallons) for White River water and $13.58 per MG for Fall Creek water. Since Big Walnut Creek Reservoir water is expected to be of better quality than either White River or the Fall Creek supplies, an estimated treatment cost of $11.00 per MG was used for this potential source.

Storage in Big Blue Reservoir is also capable of satisfying a portion of the future water supply needed for the Indianapolis area. Based on a similar calculation to that outlined for Big Walnut Reservoir an annual benefit of providing 28 mgd was determined to be $81,000. This method of satisfying water supply needs requires a pipeline of approximately nineteen miles to Fall Creek and utilizing the existing Geist Reservoir for equalizing purposes. Since the

quality of water in Big Blue Reservoir is expected to be approximately equal to that presently obtained from White River, no benefit from lower treatment costs as considered in Big Walnut Creek Reservoir was calculated.

Water Quality Control Benefits

Storage of water for quality control will result in benefits to downstream water supplies for municipal and industrial use, to those interested in fishing in the stream, to those who might desire to use the stream and shore for picnicking and boating, and to property owners along Big Walnut Creek, and Eel, Big Blue and East Fork White River because of esthetic and direct use benefits. Public health would be protected by providing a better quality of water for existing and potential future public water supplies and for general recreational use. Some of the benefits associated with these uses are tangible and can be assigned a dollar value; however, in many cases such dollar values are difficult to accurately define. Other benefits are largely intangi le and often relate to esthetic values which are difficult to assign a direct dollar value.

Use of the stream and shore for general outdoor recreation is dependent on a number of factors including accessability, amount of leisure time generally available, alternate recreational areas and area population. With a present population of over 1,300,000 and significant growth projected for the study area many people are and

will be living within easy access of the stream reaches. Esthetic enjoyment will in part depend on water quality. Degraded quality could be expected to decrease this use and result in the substitution of more remote and therefore more expensive water oriented general recreation. The value of such benefits foregone, or participated in at more cost at more remote locations in the absence of quality control, would be a partial measure of the values of releases attributable to this beneficial use.

The United States Department of the Interior, Bureau of Sport Fisheries and Wildlife, has a report in preparation on fish and wildlife resources of the Ohio River Basin including the White River Basin. Based on provisional figures, the total number of anglers in the White River Basin is expected to increase from 208,500 in 1960 to 285,300 in 1980 and to 361,300 in 2010. Actual man-hours of fishing are expected to increase from 1,440,000 in 1960 to 2,294,000 in 1980 and to 2,905,000 in 2020. Existing fishery capability is 77,600 man-hours in excess of the 1980 needs, but 533,500 short of the 2010 needs. The provisional values further consider 1,000 acres of free flowing stream in the White River Basin as having a potential commercial fishery habitat. Approximately 400 stream miles in Big Walnut Creek, Eel, Big Blue, White, and East Fork White Rivers are below the proposed reservoirs.

Many of the benefits previously described are tangible but difficult to accurately evaluate. Other benefits are intangible and valuation is dependent on personal esthetic considerations. In the absence of developed techniques to determine the value of many of the benefits, the cost of the most likely and economical alternate to providing water quality control from storage in the project reservoirs is considered the minimum value of the benefits assignable to the project.

Benefits as calculated below are based on a 50-year amortization of costs at the Federal interest rate of 3 1/8 percent and include operation and maintenance costs.

The minimum annual value of the benefit of providing water quality control below Greencastle from storage in Big Walnut Creek Reservoir was determined to be $22,300. This evaluation is based on the estimated annual cost of an upstream single-purpose water quality control structure, which is considered the most economical alternate to providing sufficient storage in Big Walnut Creek Reservoir to yield the 1,400 acre-feet draft-on-storage to meet 2020 requirements at the point of need. The first cost of the alternate structure is estimated at $380,000 and is based on a reservoir storage of 1,800 acre-feet to allow for storage and transmission losses to the point of need.

The minimum annual value of the benefit of providing water quality control below Shelbyville from storage in Big Blue Reservoir was determined to be $75,000. This evaluation is based on the estimated

annual cost of an upstream single-purpose water quality control structure, which is considered the most economical alternate to providing sufficient storage in Big Blue Reservoir to yield the 12,000 acre-feet draft-on-storage to meet 2020 requirements at the point of need. The first cost of the alternate structure is estimated at $1,500,000 and is based on a reservoir storage of 15,000 acre-feet to allow for storage and transmission losses to the point of need.

A 1964 report on Clifty Creek Reservoir[13] estimated the benefit of providing water quality control storage in Clifty Creek Reservoir as being $143,000 per year. This benefit was based on providing water quality control on Clifty Creek and the East Fork White River below Columbus. Storage in the reservoirs under study in this report would not provide any water quality control benefit to Clifty Creek, unless water were pumped from Downeyville Reservoir to the upper end of the Clifty Creek drainage basin. A value for using pumped storage would accrue to Downeyville Reservoir only if storage costs were enough lower in Downeyville Reservoir than in Clifty Creek Reservoir to more than offset pumping and pipeline costs. Storage in Big Blue Reservoir to satisfy water quality control needs below Shelbyville is a partial alternate to storage in Clifty Creek Reservoir in providing water quality control benefits on East Fork White River below Columbus. However, operation to satisfy needs below Shelbyville cannot be expected to coincide exactly with the timing of needs below Columbus.

Clifty Creek Reservoir, by being much closer to the stream reach below Columbus, would provide considerably more flexibility than trying to adjust flows by storage in Big Blue Reservoir. Provision of storage in both Big Blue and Clifty Creek Reservoirs would allow meeting all expected water quality control needs in Clifty Creek and East Fork White River and those needs on Big Blue River below Shelbyville.

For the 80,000 acre-feet of storage required for water quality control needs below Muncie and Anderson, the annual cost of pipelines to the proposed reservoirs was found to exceed the annual cost of storage in a potential reservoir site at Parker City above Muncie. Therefore, no benefit for storage to provide for this need has been attributed to the reservoirs under study. However, this need remains unmet and possibilities of meeting this need from a reservoir at Parker City or other upstream locations should be further studied.

As noted in Chapter VIII, reservoir storage is capable of meeting a portion of the water quality need for the stream reach below Indianapolis. Benefits of providing this storage from Big Walnut Creek Reservoir were found to be $280,000 using the same alternates indicated in evaluation for water supply for the Indianapolis area. The lesser benefit for water quality control ($280,000 rather than $550,000) is due to the treatment savings that are expected to be of benefit to water supply but not water quality control and because some of the pumping head which is lost in transport to the White River for water

quality control can be utilized by taking advantage of the higher terrain in the rapidly growing area west of Indianapolis and constructing new treatment facilities at an elevation to take advantage of head gained in pumping from Big Walnut Creek Reservoir. Storage in a reservoir at Parker City, as noted in the previous paragraph, would also have an additional benefit of being a partial solution to providing water quality control in the White River below Indianapolis.

The benefit of providing water quality control in the Big Walnut Creek, Eel, White, Big Blue, and East Fork White Rivers is widespread. The benefits will continue downstream on the Wabash River and to a lesser extent to the Ohio and Mississippi Rivers. All storage requirements are based on adequate treatment at the source of wastes and, therefore, are not in lieu of adequate treatment or other control measures at the source.

The needs and value of benefits as outlined in this report are based on the best estimates that can be made at this time and are subject to review and revision based on information and data from the Ohio River Basin Comprehensive Study by the Federal Water Pollution Control Administration.

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Table III-2
BIG BLUE RIVER, CARTHAGE - 1964
SURFACE WATER QUALITY

Date	Alkalinity (Total) as $CaCO_3$ mg/liter	Chlorides as Cl mg/liter	Nitrates as N mg/liter	pH	Spec. Conductance µmhos./cm.	Hardness as $CaCO_3$ mg/liter	Color	Turbidity	Susp. Matter mg/liter	Vol. Susp. Matter mg/liter	Phosphates mg/liter	BOD mg/liter	Coliform per 100 ml. (In Thousands)	Temperature--C.°	Dissolved Oxygen mg/liter	Dissolved Oxygen % Sat.	Flow cfs.
1-2	290	36	2.3	8.0	774	371	5	305	5	3	2.0	3.0	20.0	0	10.8	73	43
1-15	306	26	2.4	7.6	779	370	5	305	1	1	2.3	2.3	27.0	1	11.8	83	57
1-30	292	28	2.7	8.0	810	384	10	5	5	5	3.9	2.0	16.0	0	11.5	78	58
2-10	272	23	1.6	7.7	742	40	10	10	1	1	1.9	2.5	25.0	2	13.0	94	64
2-27	284	44	1.5	7.9	768	368	10	5	3	3	0.8	1.8	12.0	1	8.1	57	54
3-10	62	6	2.1	7.1	235	110	25	360	172	32	0.5	3.7	36.0	2	12.0	87	4,270
3-25	256	18	2.5	7.8	725	340	0	5	11	3	0.5	0.7	15.0	12	11.2	104	170
4-7	172	10	4.9	7.9	481	242	30	60	40	7	0.3	2.3	35.0	11	9.7	87	570
4-23	136	7	1.8	7.6	424	208	40	130	72	17	0.6	2.0	23.0	14	8.0	77	1,460
5-4	244	10	1.2	7.7	619	316	5	15	16	4	0.5	0.9	15.0	16	8.3	83	287
5-21	270	26	1.2	7.8	618	340	10	10	8	3	0.5	1.9	20.0	18	9.3	97	125
6-4	262	15	2.0	8.0	642	328	10	10	9	3	0.4	1.0	20.0	20	8.7	95	100
6-18	278	20	1.8	8.0	706	346	5	20	14	26	0.7	2.1	22.0	21	8.4	94	82
7-3	292	12	1.4	8.0	665	352	10	10	11	8	0.7	1.1	13.0	23	7.8	90	60
7-16	240	9	2.6	7.7	580	294	10	40	12	5	1.0	2.0	22.0	21	7.7	86	150
7-30	286	29	0.5	8.1		352	5	5	3	3	0.9	0.0	3.6	22	11.0	125	58
8-13	284	33	1.3	7.8	714	336	10	20	13	8	2.0	1.6	34.0	18	9.5	99	47
8-24	272	13	1.5	7.5	683	330	5	30	23	6	0.8	2.3	6.3	20	8.0	87	41
9-10	294	37	2.1	7.8	662	356	10	10	18	8	0.8	1.2	23.0				33
9-28	304	33	1.6	8.1	821	358	10		10	5	0.8	1.4	1.8	15	12.0	118	36
10-13	298	33	1.9	7.5	735	368	15	5	12	7	1.0	2.2	4.7	10	7.8	69	38
10-26	336	33	1.4	8.4	767	386	15	5	5	3	0.6	1.5	6.5	12	7.1	66	35
11-12	288	35	0.9	7.9	692	390	10	5	9	3	1.2	1.3	16.0	12	6.8	62	36
11-24	294	23	1.1	8.0	753	360	5	5	3	3	0.8	1.6	18.0	1	9.4	66	43
12-7	282	26	1.6	7.6	700	352	5	5	5	2	0.5	1.6	5.6	1	8.6	60	45
12-21	292	34	2.7	8.1	789	378	5	5	6	4	0.3	2.9	24.0	0	10.3	70	46

Table III-1
EEL RIVER (LOWER WHITE RIVER BASIN)
NORTHINGTON - 1964
SURFACE WATER QUALITY

Date	Alkalinity (Total) as CaCO3 mg/liter	Chlorides as Cl- mg/liter	Nitrates as N mg/liter	pH	Spec. Conductance mhos./cm	Hardness as Ca CO3 mg/liter	Color	Turbidity	Susp. Matter mg/liter	Vol. Susp. Matter mg/liter	Phosphates	BOD mg/liter	Coliform per 100 ml (In thousands)	Temperature - C.°	Dissolved Oxygen mg/liter	% Sat.
1- 7	232	15	0.4	8.0	561	204	10	305	4	3	1.1	1.9	0.11	0	21.4	146
1-21	158	16	1.2	8.1	486	234	15	10	14	4	0.6	4.0	3.8	0	12.3	84
2- 4	182	16	1.0	8.0	572	252	10	5	3	1	7.2	1.5	< 0.1	2	13.0	94
2-18	158	22	1.0	8.0	582	272	10	5	9	4	1.4	1.3	<1.0	2	13.9	100
3- 3	174	14	0.2	8.4	508	238	5	10	18	4	0.2	2.5	1.0	9	13.9	120
3-17	126	8	2.3	7.4	416	202	10	90	96	9	0.1	2.0	2.0	8	9.5	80
3-31	112	8	2.0	7.6	392	192	5	105	122	10	0.2	2.1	0.7	5	11.9	96
4-14	180	9	2.0	7.7	338	262	5	60	59	7	0.8	1.7	1.2	14	8.7	84
4-28	94	4	0.5	7.6	301	150	20	280	222	18	0.3	3.3	7.0	17	7.3	75
5-12	118	5	1.7	7.6	331	158	15	40	82	9	0.2	3.2	6.0	18	8.4	88
5-26	214	8	0.2	8.0	530	286	5	50	63	23	0.1	6.7	1.0	23	12.3	142
6- 9	228	25	1.7	8.0	650	312	5	100	90	15	1.0	4.0	3.0	27	11.0	136
6-23	150	8	1.3	8.0	438	205	15	300	165	6	0.2	2.6	18.0	29	6.2	80
7- 7	154	6	0.4	7.9	468	232	10	10	102	14	0.8	2.5	16.0	24	7.3	85
7-21	206	27	1.3	8.5	553	270	10	40	53	17	0.7	5.4	7.0	29	8.0	103
8-18	260	11	0.1	7.9	565	330	10	80	51	7	0.4	2.7	1.0	26	9.5	116
9- 2	232	9	0.2	8.4	495	264	10	80	59	13	0.0	4.4	1.2	25	8.5	101
9-15	264	12	0.0	7.6	530	311	10	35	51	13	0.0	3.3	1.0	20	9.3	101
9-24	268	10	0.0	8.1	568	300	5	70	45	9	1.5	1.8	2.7	19	7.3	78
10- 6	252	9	0.1	8.2	354	298	5	25	16	6	0.2	3.9	0.2	14	7.4	72
10-20	150	12	0.2	7.7	340	176	20	30	96	11	--	2.2	2.2	13	6.8	63
11- 2	238	9	0.0	8.0	505	276	7	25	39	4	1.1	1.4	4.0	15	6.0	59
11-17	236	11	0.2	7.9	562	292	5	60	52	7	0.1	1.4	3.0	12	5.9	54
12-1	232	14	0.0	8.0	568	288	5	0	0	0	0.2	15.0	< 0.1	0	10.0	68
12-15	220	24	0.3	8.1	617	298	10	5	4	2	---	3.7	0.1	0	8.6	59
12-29	180	20	0.7	8.0	561	286	5	5	7	4	0.3	1.1	1.0	4	11.1	85

Table III-3

BIG BLUE RIVER, MORRISTOWN - 1964

SURFACE WATER QUALITY

Date	Alkalinity (Total) as Ca CO_3 mg/liter	Chlorides as Cl- mg/liter	Nitrates as N mg/liter	pH	Spec. Conductance umhos./cm.	Hardness as $CaCO_3$ mg/liter	Color	Turbidity	Susp. Matter mg/liter	Vol. Susp. Matter mg/liter	Phosphates	BOD mg/liter	Coliform per 100 ml.(In Thousands)	Temperature - C°	Dissolved Oxygen mg/liter	Dissolved Oxygen % Sat.
1- 2	---	--	---	---	---	--	--	---	RIVER FROZEN			---	---	----	----	--
1-15	---	--	---	---	---	--	--	---	RIVER FROZEN			---	---	----	----	--
1-30	320	29	3.4	8.2	951	372	30	5	3	6	4.8	6.0	3.1	0	11.8	80
2-10	280	22	1.4	7.6	723	282	35	10	3	3	1.2	3.5	4.8	2	13.3	96
2-27	286	26	1.2	7.8	729	376	--	5	9	8	0.5	3.2	0.5	1	7.3	51
3-10	---	--	---	---	---	---	--	--	FLOODED ROAD			---	---	---	----	--
3-25	282	16	3.0	8.2	967	298	25	10	11	4	0.5	2.0	6.7	12	8.9	82
4- 7	178	9	4.7	7.4	502	230	--	80	58	12	0.1	7.0	60.0	12	7.4	69
4-23	142	6	3.7	7.2	392	160	--	130	50	12	0.6	5.0	18.0	15	4.0	39
5- 4	246	12	1.6	7.5	601	298	--	10	15	5	0.4	1.1	9.8	18	5.4	55
5-21	286	22	0.9	7.8	730	334	25	10	9	3	0.3	3.8	3.2	19	5.4	58
6- 4	254	14	1.7	7.9	642	310	10	10	18	5	0.5	1.5	3.7	--	----	--
6-18	292	19	1.6	7.9	863	320	5	30	26	15	0.6	2.6	2.6	21	7.8	87
7- 3	290	16	1.4	8.0	634	346	5	15	15	7	1.0	2.6	0.6	24	5.8	68
7-16	238	7	3.9	7.6	565	284	15	40	45	8	2.0	1.3	30.0	21	7.6	85
7-30	276	18	0.3	8.0	---	340	10	5	3	3	0.3	0.0	1.3	24	9.0	106
8-13	230	10	0.7	7.7	540	270	25	30	21	9	1.4	2.0	22.0	18	6.5	68
8-24	262	22	1.8	7.4	756	340	10	15	14	4	0.5	2.1	1.1	22	6.0	68
9-10	306	26	1.4	7.7	662	344	20	20	14	8	0.9	1.7	1.5	---	----	--
9-28	296	25	1.4	8.1	773	348	15	10	11	5	0.2	1.4	2.4	16	11.0	111
10-13	310	27	1.6	7.8	753	352	20	10	17	8	0.6	2.6	0.2	11	10.8	97
10-26	348	29	1.4	8.5	750	372	25	5	7	4	0.5	2.7	0.3	12	5.3	49
11-12	312	26	0.7	7.6	692	360	15	5	9	5	2.3	1.3	0.7	13	6.5	62
11-24	290	24	0.8	8.0	753	356	25	30	11	5	2.8	4.3	0.4	2	8.8	64
12- 7	286	25	1.7	7.6	687	344	20	5	6	3	0.5	2.7	1.5	2	----	--
12-21	306	25	2.1	8.0	789	380	25	5	6	3	0.6	4.5	2.2	0	9.4	65

Table III-4

BIG BLUE RIVER, SHELBYVILLE - 1964

SURFACE WATER QUALITY

Date	Alkalinity (Total) as $CaCO_3$ mg/liter	Chlorides as Cl- mg/liter	Nitrates as N mg/liter	pH	Spec. Conductance umhos./cm	Hardness as $CaCO_3$ mg/liter	Color	Turbidity	Susp. Matter mg/liter	Vol. Susp. Matter mg/liter	Phosphates	BOD mg/liter	Coliform per 100 ml. (In Thousands)	Temperature - C°	Dissolved Oxygen		Flow cfs.
															mg/liter	% Sat.	
1- 2	311	43	2.1	8.1	---	803	--	5	5	4	1.1	5.3	1.1	0	11.1	76	51
1-15	280	25	1.7	7.7	706	340	25	5	2	1	1.4	3.1	2.1	1	12.2	85	71
1-30	286	22	1.7	8.1	810	358	30	3	4	5	4.0	5.5	0.5	1	17.2	121	93
2-10	246	21	1.5	8.1	625	300	25	5	4	3	1.1	4.1	0.6	3	16.9	125	106
2-27	274	24	0.8	8.2	706	344	--	5	2	2	0.4	4.3	0.9	3	11.5	90	87
3-10	90	19	2.7	7.5	266	112	--	550	282	56	0.5	6.7	20.0	4	11.6	89	5,420
3-25	234	15	3.0	8.1	687	302	10	10	13	4	0.3	2.7	11.0	12	11.3	105	425
4- 7	176	10	5.7	7.7	525	236	--	70	45	9	0.8	4.7	28.0	14	10.2	98	1,760
4-23	126	5	0.9	7.4	342	148	--	170	44	13	1.1	4.1	< 1.0	17	5.8	59	6,600
5- 4	240	10	1.6	7.8	601	308	--	15	18	4	0.4	2.6	2.0	20	8.0	87	620
5-21	274	13	1.7	8.3	683	322	15	5	12	4	0.2	3.9	0.5	22	9.8	111	223
6- 4	262	14	2.2	8.2	---	316	10	5	5	3	0.3	4.3	0.6	19	11.5	123	167
6-18	264	14	1.3	8.1	706	274	5	10	13	25	0.5	3.1	4.6	24	9.2	108	133
7- 3	272	14	1.8	8.3	589	326	10	5	10	5	0.0	3.4	1.0	27	8.8	109	93
7-16	122	4	3.1	8.2	522	266	15	20	34	9	0.6	3.2	20.0	25	8.4	100	550
7-30	248	16	0.6	8.2	---	300	15	5	6	6	0.5	1.8	0.7	25	8.2	97	111
8-13	208	17	0.7	7.8	512	250	25	20	11	7	0.7	4.7	0.8	22	10.0	113	96
8-24	262	10	1.5	7.7	662	320	15	10	11	5	0.3	1.9	2.1	25	9.1	109	74
9-10	276	23	1.2	8.0	642	324	15	15	10	6	0.3	3.6	3.2	--	----	---	46
9-28	316	21	1.5	8.0	696	316	15	5	9	5	0.4	2.3	1.3	15	9.3	92	52
10-13	286	23	1.6	7.9	678	332	15	5	14	8	0.3	4.8	0.1	14	8.8	85	45
10-26	314	23	1.1	8.2	682	358	25	5	6	4	0.4	2.2	0.1	70	6.4	56	53
11-12	286	25	0.7	8.0	648	358	15	5	6	4	0.2	3.3	0.6	13	7.1	67	58
11-24	278	21	1.0	8.2	706	344	10	10	--	--	0.2	1.8	< 0.1	3	10.7	79	73
12- 7	282	26	1.2	7.7	680	346	25	5	5	3	0.7	2.8	0.2	2	9.6	69	94
12-21	292	24	2.0	8.2	672	376	20	5	9	4	0.2	4.4	0.1	0	9.6	66	83

Table III-5
WHITE RIVER, MUNCIE - 1964
SURFACE WATER QUALITY

Date	Alkalinity (total) as $CaCO_3$ mg/liter	Chlorides as Cl mg/liter	Nitrates as N mg/liter	pH	Spec. Conductance µmhos./cm.	Hardness as $CaCO_3$ mg/liter	Color	Turbidity	Susp. Matter mg/liter	Vol. Susp. Matter mg/liter	Phosphates	A.B.S.	BOD mg/liter	Coliform per 100 ml. (In Thousands)	Temperature--C.°	Dissolved Oxygen mg/liter	Dissolved Oxygen % Sat.	Flow cfs.
1-9	264	57	0.4	7.7	847	380	30	25	16	11	3.4	1.0	>27.0	260.0	3	8.3	61	26
1-23	206	34	1.8	8.2	682	300	20	10	7	6	2.6	0.5	5.9	24.0	2	13.0	94	90
2-6	200	34	0.5	7.9	636	282	35	40	34	16	3.4		11.0	110.0	3	10.5	78	48
2-20	276	71	0.6	8.0	961	396	25	5	10	5	2.7	1.5	44.0	67.0	3	11.4	85	14
3-5	114	14	7.0	7.7	421	214	35	450	308	66	0.3	0.5	6.5	50.0	5	10.0	78	1,370
3-19	198	18	4.6	7.9	597	306	5	20	15	4	0.4	0.5	3.4	10.0	5	7.2	57	199
4-2	204	20	2.1	7.8	630	322	5	20	27	6	0.5	0.5	5.3	50.0	7	12.1	100	161
4-16	222	18	2.0	8.0	662	292	10	10	13	7	0.8	0.0	2.5	44.0	13	11.5	109	112
4-30	166	7	2.3	7.7	478	236	15	60	34	6	0.3	0.5	2.0	14.0	13	9.2	87	849
5-14	250	24	1.2	8.1	746	350	10	20	15	8	0.8	0.5	5.3	32.0	19	12.1	129	99
5-28	256	28	1.2	8.2	718	352	5	10	4	4	0.4	0.5	3.5	34.0	19	10.4	111	44
6-11	202	27	1.3	8.3	653	282	10	5	4	5	0.7	0.3	5.3	20.0	25	14.5	173	46
6-24	222	27	6.0	8.1	638	302	5	40	28	7	0.5	0.4	4.2	20.0	25	8.2	97	69
7-8	164	48	2.5	7.6	557	214	15	5	54	15	1.8	0.2	12.0	62.0	20	6.8	74	210
7-22	164	36	0.4	7.7	736	360	15	10	13	7	1.0	0.2	3.0	2.5	28	8.2	103	12
8-6	192	53	1.0	8.0	730	324	20	15	16	9	0.5	0.5	6.0	48.0	29	13.0	167	14
8-19	226	45	0.6	7.9	746	374	20	15	5	4	1.5	0.5	3.4	30.0	25	9.5	110	3
9-4	220	50	0.8	8.3	743	360	15	5	3	2	1.2	0.3	5.0	3.0	26	13.5	164	3
9-17	244	44	0.7	8.2	756	382	15	5	8	4	0.9	0.4	4.4	3.0	22	13.6	143	3
9-22	202	37	0.6	7.8	662	320	10	0	7	7	1.1	0.3	4.2	180.0	24	7.3	85	13
10-8	302	59	2.1	8.0	574	372	15	15	21	11	6.5	0.4	56.0	14.0	13	11.0	104	15
10-21	252	43	1.1	7.5	720	352	15	5	5	4	1.3	0.5	2.2	82.0	13	6.2	59	90
11-4	250	44	0.5	7.4	790	394	10	5	4	2	1.7	0.4	5.7	2.2	13	2.4	23	87
11-18	224	39	0.7	8.1	693	336		5	5	5	1.3		2.3	130.0	10	7.1	63	16
12-3	234	43	0.4	8.3	729	354	10	10	3	0	0.6	0.3	4.4	49.0	0	9.1	63	13
12-17	250	48	0.6	8.1	835	406	10	10	4	4	1.3	0.5	1.5	28.0	0	10.0	68	10
12-29	250	42	0.8	8.2	720	362	10	10	—	—	1.6	0.0	8.3	110.0	9	10.9	94	10

Table III-6
WHITE RIVER, ANDERSON - 1964
SURFACE WATER QUALITY

Date	Alkalinity (total) as $CaCO_3$ mg/liter	Chlorides as Cl mg/liter	Nitrates as N mg/liter	pH	Spec. Conductance µmhos./cm.	Hardness as $CaCO_3$ mg/liter	Color	Turbidity	Susp. Matter mg/liter	Vol. Susp. Matter mg/liter	Phosphates	BOD mg/liter	Coliform per 100 ml. (In Thousands)	Temperature--C.°	Dissolved Oxygen mg/liter	Dissolved Oxygen % Sat.	Flow cfs.
1-9								RIVER FROZEN									
1-23	222	50	1.8	8.1	821	342	20	5	9	7	7.0	5.8	53.0	0	10.3	70	107
2-6	250	50	1.0	8.0	852	365	20	25	20	4	5.6	4.6	14.0	4	10.4	79	104
2-20	274	93	1.8	8.0	1,027	384	20	5	3	3	4.6	3.5	1.0	2	14.1	102	75
3-5	150	22	4.9	7.6	527	278	25	450	488	128	0.6	27.0	130.0	6	5.8	46	1,550
3-16	202	22	4.0	7.9	665	324	10	20	11	3	1.0	2.6	16.0	5	6.7	52	474
4-2	242	28	2.3	7.8	718	376	5	5	13	7	2.0	3.0	18.0	7	10.8	89	262
4-16	244	24	2.0	7.9	730	368	10	10	21	15	2.1	3.9	22.0	14	9.2	89	230
4-30	178	10	2.6	7.6	501	268	15	60	30	7	0.5	2.7	64.0	13	8.4	80	1,440
5-14	252	24	1.6	8.2	733	356	10	20	14	8	0.8	4.2	34.0	79	14.9	160	278
5-28	260	32	1.6	8.0	756	340	20	10	9	7	4.5	4.9	30.0	19	5.1	55	138
6-11	274	30	1.1	8.1	796	360	15	10	13	10	0.3	4.3	2.0	25	11.7	139	134
6-24	252	26	3.4	8.0	726	332	10	30	16	6	1.9	4.7	50.0	26	4.1	50	168
7-8	170	29	2.9	7.5	501	228	20	5	51	15	1.7	18.0	130.0	20	3.2	35	532
7-22	264	31	1.8	8.0	736	356	15	40	43	17	1.5	2.5	2.7	28	5.6	71	97
8-6	372	52	1.4	8.6	814	374	20	25	21	11	5.0	7.2	15.0	29	12.2	156	81
8-19	270	54	1.6	8.1	836	366	20	30	25	10	5.0	4.4	4.0	23	11.1	128	72
9-4	252	54	0.7	8.1	716	340	15	40	57	34		16.0	18.0	26	20.5	245	75
9-17	292	60	1.5	8.5	815	354	20	90	79	71	1.7	18.0	1.0	21	23.7	264	56
9-22	196	42	0.8	8.7	642	278	15	30	73	60	2.9	20.0	10.0	25	27.0	322	49
10-8	302	59	2.1	8.0	574	372	15	20	20	10	6.5	4.9	25.0	12	11.2	104	51
10-21	300	62	1.9	7.6	870	362	20	30	14	6	6.0	15.0		11	6.2	56	78
11-4	282	58	1.3	7.7	926	380	10	15	23	6	1.5	6.1	6.4	14	5.8	56	72
11-18	234	42	0.6	8.0	700	302		10	11	6	2.6	4.8	160.0	10	4.0	35	90
12-2	266	54	2.1	8.3	781	362	15	10	0	0	6.5	2.0	41.0	0	11.0	75	75
12-17	260	47	1.3	8.2	845	398	10	5	3	3	6.5	1.6	6.9	0	9.6	66	75
12-29	258	35	2.0	7.9	780	396	10	5	—	—	3.0	5.3	31.0	7	8.9	73	78

Table III-7
WHITE RIVER, NOBLESVILLE - 1964
SURFACE WATER QUALITY

Date	Alkalinity (total) as $CaCO_3$ mg/liter	Chlorides as Cl mg/liter	Nitrates as N mg/liter	pH	Spec. Conductance µmhos./cm.	Hardness as $CaCO_3$ mg/liter	Color	Turbidity	Susp. Matter mg/liter	Vol. Susp. Matter mg/liter	Phosphates	BOD mg/liter	Coliform per 100 ml. (In Thousands)	Temperature--C.°	Dissolved Oxygen mg/liter	Dissolved Oxygen % Sat.	Flow cfs.
1-8	284	78	0.8	7.7	921	362	30	305	5	4	9.5	3.3	0.3	2	7.6	55	100
1-22	233	64	1.8	8.1	852	310	20	10	7	4	9.0	5.1	4.8	0	8.0	55	180
2-5	260	55	0.9	7.9		904	20	5	8	4	3.2	2.3	0.2	1	10.4	73	159
2-19	276	58	1.8	8.0	922	372	20	5	3	2	3.3	2.8	<1.0	2	12.8	93	139
3-4	224	45	1.6	7.8	768	326	20	10	14	9	6.5	7.3	1.6	8	12.8	108	610
3-18	154	16	5.6	7.9	518	260	15	30	29	6	0.9	3.5	51.0	3	7.7	57	1,810
4-1	230	22	3.6	7.5	682	350	5	5	10	10	1.4	2.7	0.6	4	9.9	75	505
4-15	204	28	3.0	7.8	706	334	10	10	16	7	1.9	2.8	1.3	13	8.9	84	765
4-29	132	8	2.2	7.8	421	206	25	140	85	17	0.8	3.6	5.0	14	7.9	87	4,220
5-13	224	20	1.4	8.1	663	332	15	40	33	12	1.2	5.1	1.9	18	10.3	105	680
5-28	272	27	2.3	8.0	743	360	15	15	11	6	2.4	4.0	2.9	20	7.8	85	680
6-10	266	26	1.1	8.1	842	340	10	15	21	8	2.1	3.6	0.7	25	9.7	116	289
6-24	218	24	3.0	7.8	601	302	10	50	50	10	1.0	5.3	2.6	26	5.6	68	530
7-1	230	27	0.8	8.7	706	360	15	50	33	16	1.0	6.6	1.0	28	9.7	124	187
7-22	266	25	1.6	8.0	687	342	15	30	26	9	4.5	5.3	4.0	27	7.5	93	321
8-5	234	34	1.4	8.0	847	298	25	15	16	6	4.0	3.1	<0.1	29	4.3	56	163
8-20	294	56	1.2	7.4	803	374	25	40	33	17	0.0	6.0	3.0	26	16.0	195	137
9-3	292	46	1.4	8.0	802	356	15	10	31	10	2.1	1.3	0.2	24	6.9	80	122
9-16	320	58	0.7	8.3	815	364	15	30	26	13	1.9	1.2	0.5	19	10.5	112	95
9-21	276	62	0.8	7.8	883	348	20	10	23	12	6.0	9.7	3.7	22	6.9	78	150
10-7	310	65	1.4	7.9	591	378	20	10	18	9	7.5	6.1	30.0	12	4.9	45	83
10-22	316	56	2.1	7.7	836	368	25	10	8	4	6.5	3.3	1.3	11	7.8	70	91
11-5	312	59	1.5	7.8	926	380	15	10	10	5		3.4	1.1	14	5.0	48	102
11-18	286	57	0.4	8.0	868	398		10	8	5	2.5	5.3	130.0	11	3.8	34	173
12-2	298	54	1.4	8.1	791	342	20	5	0	0	4.6	2.6	1.0	3	6.5	49	119
12-16	278	65	1.9	8.0	903	368	20	5	5	5	2.3		0.1	2	8.0	58	155
12-29	220	38	1.8	7.9	650	324	10	5	—	—	2.8	6.6	1.8	6	8.8	70	170

Table III-8
WHITE RIVER, NORA - 1964
SURFACE WATER QUALITY

Date	Alkalinity (total) as $CaCO_3$ mg/liter	Chlorides as Cl mg/liter	Nitrates as N mg/liter	pH	Spec. Conductance µmhos./cm.	Hardness as $CaCO_3$ mg/liter	Color	Turbidity	Susp. Matter mg/liter	Vol. Susp. Matter mg/liter	Phosphates	A.B.S.	BOD mg/liter	Coliform per 100 ml. (In Thousands)	Temperature--C.°	Dissolved Oxygen mg/liter	Dissolved Oxygen % Sat.	Flow cfs.
1-8	280	53	0.8	7.7	815	330	25	305	6	5	5.0		4.5	0.6	0	12.2	83	150
1-22	266	56	1.4	8.1	886	360	25	5	5	2	9.0	1.5	2.7	1.9	0	10.6	72	240
2-5	274	48	1.3	7.8	869	356	20	5	1	0	4.0	1.0	1.6	0.3	1	12.5	87	154
2-19	292	45	1.9	7.8	837	360	25	5	3	2	4.2	1.5	2.6	<1.0	2	14.4	104	170
3-4	258	46	1.7	7.7	796	340	25	10	12	7	7.5	0.5	4.7	2.4	7	12.5	103	615
3-18	164	15	4.4	7.8	501	230	15	30	28	6	0.5	0.5	2.7	23.0	4	6.4	49	2,710
4-1	202	18	4.1	7.3	602	280	10	25	31	9	0.2	0.5	2.0	1.8	4	9.9	75	845
4-15	206	18	3.0	7.8	642	306	10	10	20	7	1.0		2.8	1.8	12	8.7	80	975
4-29	168	10	1.9	8.3	468	208	25	115	82	17	1.2	0.5	6.7	3.9	14	8.1	78	6,180
5-13	232	16	1.0	8.1	633	314	15	40	25	16	0.7	0.5	5.6	3.4	18	10.6	108	910
5-28	260	22	2.4	8.2	706	344	10	15	17	9	1.2	0.3	4.5	2.8	20	9.8	107	444
6-10	260	28	2.2	8.2	796	336	15	15	21	9	1.9	0.2	3.6	1.4	25	10.3	123	380
6-24	190	18	4.0	7.8	601	260	15	70	61	13	0.8	0.4	3.3	2.6	26	5.7	69	785
7-1	256	31	0.8	8.0	330	330	10	50	29	15	1.1		6.4	1.2	27	11.0	136	288
7-22	260	21	1.4	8.5	644	302	25	30	32	17	1.0	0.2	3.5	0.5	27	10.5	130	421
8-5	204	28	0.5	8.4	756	278	20	25	4	1	0.8	0.5	4.0	0.2	28	8.2	103	218
8-20	284	43	0.8	8.6	746	350	25	40	38	20		0.3	7.7	2.0	25	17.7	211	164
9-3	290	47	0.4	8.5	802	352	15	20	25	8	2.1	0.2	4.2	0.2	23	12.5	145	177
9-16	278	37	0.1	8.2	683	312	15	40	40	15	1.3	0.3	4.5	0.1	19	11.0	118	120
9-21	278	50	0.9	8.2	815	348	20	20	28	12	2.0	0.5	2.8	<0.1	22	7.3	82	228
10-7	288	49	1.9	8.1	534	354	25	10	27	16	3.1	0.4	6.1	1.0	13	8.1	77	114
10-23	320	56	1.5	7.7	870	372	20	15	9	4	6.0	0.8	3.5	1.1	11	7.1	64	120
11-5	308	55	1.0	7.7	888	400	25	10	14	7	9.0	1.0	5.3	0.8	14	6.4	62	138
11-18	284	58	1.3	8.0	868	364		10	15	8	2.6	0.3	3.1	5.0	10	5.0	44	187
12-2	280	54	1.6	7.9	810	360	15	5	0	0	3.8	0.7	4.2	0.9	0	9.4	65	164
12-16	294	66	2.0	7.7	903	374	20	5	6	6		0.5	3.0	0.1	3	7.2	53	151
12-29	238	42	2.0	8.0	740	360	15	10	—	—	2.7	0.0	6.3	3.0	6	10.2	82	214

Table III-9
WHITE RIVER, ANTRIM - 1964
SURFACE WATER QUALITY

Date	Alkalinity (total) as $CaCO_3$ mg/liter	Chlorides as Cl mg/liter	Nitrates as N mg/liter	pH	Spec. Conductance µmhos./cm.	Hardness as $CaCO_3$ mg/liter	Color	Turbidity	Susp. Matter mg/liter	Vol. Susp. Matter mg/liter	Phosphates	A.B.S.	BOD mg/liter	Coliform per 100 ml. (In Thousands)	Temperature--C.°	Dissolved Oxygen mg/liter	Dissolved Oxygen % Sat.
1-2	331	122	0.4	7.9	1,393	402	25	5	5	5	15.0	—	5.0	110.0	5	3.9	30
1-15	314	65	0.3	7.4	1,189	115	25	5	5	4	4.0	1.5	10.0	220.0	12	1.3	12
1-30	276	110	0.6	7.9	1,152	352	50	15	13	9	1.3	2.0	9.0	170.0	11	5.2	47
2-3	284	82	0.5	7.6	1,033	322	40	20	12	9	2.0	2.0	5.0	67.0	11	3.0	27
2-17	244	198	1.1	7.5	1,331	320	25	20	19	12	6.5	3.0	13.0	1,200.0	9	2.5	21
3-2	326	87	0.4	7.4	1,076	356	15	10	12	8	1.0	1.5	7.0	240.0	15	0.0	0
3-16	122	13	4.0	7.3	416	188	15	80	58	8	0.5	0.5	3.2	44.0	7	11.5	94
3-30	200	27	5.8	7.5	652	280	10	30	16	6	1.5	0.5	3.1	21.0	6	12.1	97
4-13	200	25	3.6	7.3	409	280	15	40	28	9	1.6	1.3	4.7	310.0	14	9.0	87
4-27	148	19	1.8	7.8	468	238	20	100	61	14	1.5	0.5	4.0	200.0	15	8.2	81
5-11	242	26	2.0	8.2	662	306	10	30	31	14	1.0	0.5	7.7	190.0	21	7.8	87
5-25	272	36	1.7	8.0	770	326	20	15	13	6	1.1	1.3	11.0	75.0	25	5.8	69
6-9	258	55	1.3	7.9	853	336	15	30	25	11	5.5	0.8	7.6	880.0	31	5.4	72
6-23	203	34	1.6	8.0	663	256	15	10	34	4	1.2	0.4	10.0	770.0	31	6.0	80
7-7	222	46	0.5	7.7	743	294	20	15	23	12	3.8	0.3	4.0	1,100.0	28	3.4	42
7-21	208	33	2.0	8.1	620	380	30	30	42	18	0.8	0.5	9.0	2,500.0	32	7.3	99
8-4	268	86	0.5	7.7	622	342	25	10	21	10	7.0	12.5	5.7	330.0	36	5.8	83
8-18	152	29	0.3	7.4	4,178	180	20	10	8	2	0.3	0.2	1.3	620.0	32	6.0	81
9-2	296	200	0.5	8.2	1,096	364	20	20	16	14	18.0	0.5	4.9	93.0	32	8.2	111
9-15	292	96	0.7	7.7	1,009	367	25	15	15	7	7.0	2.0	5.9	380.0	28	6.1	77
9-24	230	74	0.3	7.6	852	288	20	10	14	1	6.0	1.0	6.9	740.0	25	3.0	36
10-6	306	92	0.3	8.0	678	376	25	20	8	4	8.0	1.1	3.5	170.0	25	4.7	56
10-20	288	86	0.4	7.7	983	344	30	15	12	8	—	1.0	4.0	190.0	21	2.8	31
11-2	328	104	0.0	7.8	1,110	378	20	10	9	5	13.0	1.2	2.9	220.0	23	1.7	20
11-17	208	60	0.5	7.5	755	254	10	50	32	13	15.0	2.0	14.0	2,500.0	16	3.1	31
12-1	312	95	0.3	7.7	1,094	368	25	15	5	4	13.0	1.1	11.0	310.0	12	5.1	47
12-15	306	100	0.4	8.2	1,164	394	25	10	12	8	7.2	1.0	3.4	22.0	10	3.2	29
12-29	280	85	1.3	8.0	939	356	—	10	16	8	—	1.0	6.7	1,700.0	9	5.3	46

Table III-10
WHITE RIVER, MARTINSVILLE - 1964
SURFACE WATER QUALITY

Date	Alkalinity (total) as $CaCO_3$ mg/liter	Chlorides as Cl mg/liter	Nitrates as N mg/liter	pH	Spec. Conductance µmhos./cm.	Hardness as $CaCO_3$ mg/liter	Color	Turbidity	Susp. Matter mg/liter	Vol. Susp. Matter mg/liter	Phosphates	A.B.S.	BOD mg/liter	Coliform per 100 ml. (In Thousands)	Temperature--C.°	Dissolved Oxygen mg/liter	Dissolved Oxygen % Sat.	Flow cfs.
1-7	312	117	0.5	8.0	1,216	382	50	5	7	5	6.0	1.5	5.4	130.0	11	9.6	86	340
1-21	298	120	0.4	8.1	1,099	348	40	10	13	7	9.5	2.0	9.3	32.0	12	8.0	74	586
2-4	254	73	0.7	8.0	921	316	25	5	3	2	8.2	1.5	2.7	6.3	7	9.1	75	396
2-18	272	91	4.6	7.9	1,035	354	25	5	8	6	2.5	2.0	5.9	4.0	11	8.3	75	488
3-3	266	78	0.4	7.9	961	346	20	5	16	6	8.5	1.0	10.0	13.0	15	8.7	86	584
3-17	126	14	3.7	7.5	423	202	15	110	104	35	0.6	1.0	5.8	100.0	9	9.9	86	8,850
3-31	206	24	2.7	7.8	642	292	5	30	25	6	1.2	0.5	2.1	0.1	9	10.6	91	2,070
4-14	228	25	2.7	8.2	415	306	10	40	49	11	2.0	0.3	4.6	69.0	16	7.8	78	2,470
4-28	154	23	1.6	7.6	438	222	20	200	140	20	1.1	0.5	3.9	360.0	17	7.8	80	9,580
5-26	248	33	2.8	7.9	730	332	10	30	20	7	1.1	1.0	6.3	29.0	28	5.5	69	1,130
6-9	252	41	2.2	7.9	758	336	10	30	29	12	1.2	0.8	6.3	18.0	30	6.0	79	916
6-23	200	24	2.5	7.9	576	268	15	70	56	21	0.9	0.4	10.0	28.0	32	5.0	68	1,920
7-7	210	43	1.1	7.8	711	298	10	10	22	10	1.2	0.3	5.0	0.8	27	6.1	75	833
7-21	208	26	2.2	8.5	553	272	30	30	46	16	1.8	0.3	5.3	4,000.0	32	8.2	111	1,290
8-4	244	54	1.5	7.8	778	330	20	10	52	10	2.0	0.5	5.0	1.1	36	6.0	86	491
8-12	224	20	1.7	7.7	623	302	10	60	59	9	1.0	0.3	8.0	25.0	21	7.0	78	2,540
8-18	254	77	2.2	7.7	995	338	15	20	21	7	3.4	0.5	7.7	4.0	30	11.5	151	367
9-2	284	81	2.8	8.2	932	358	20	15	24	10	10.0	0.4	18.0	0.2	32	5.4	73	364
9-15	268	89	1.6	7.9	963	386	20	20	21	9	5.5	1.5	7.0	11.0	26	7.2	87	294
9-24	308	71	1.1	7.8	886	336	15	10	24	9	7.0	0.5	16.0	13.0	25	5.7	68	430
10-6	208	99	2.0	8.0	678	366	15	30	15	6	7.5	0.8	13.0	1.5	22	4.5	51	295
10-20	316	100	1.6	7.9	1,080	370	25	10	14	7		1.0	13.0	1.0	19	4.6	49	329
11-2	308	8	1.3	7.9	1,110	374	40	25	10	5	28.0	1.0	14.0	60.0	20	3.5	38	272
11-17	264	78	0.5	7.7	958	328	10	40	28	13	11.0	2.5	19.0	1,900.0	17	2.5	26	842
12-1	306	87	0.7	7.8	994	362	20	15	0	0	11.5	1.0	5.3	0.1	9	7.9	68	358
12-15	250	87	0.3	7.8	970	328	20	10	6	4	12.0	0.5	8.0	200.0	8	4.5	38	444
12-29	214	53	1.6	8.0	708	310	10	5	10	8	3.0	1.0	3.9	27.0	8	7.7	65	541

Table III-11
FLATROCK RIVER
SURFACE WATER QUALITY

Date	Temp. C.°	Specific Conductance mhos./1 cm.	Dissolved Oxygen mg/1	% Sat.	Alkalinity as $CaCO_3$ mg/1	Chlorides as Cl mg/1	Hardness as $CaCO_3$ mg/1	B.O.D. 5-day mg/1	pH
Flatrock River at 400 N. Road, Columbus, Indiana									
9-7-64	20	500	8.1	88	212	16	—	3.5	7.5
9-8-64	20	500	8.2	89	200	17	278	2.5	—
9-9-64	21	510	8.2	91	222	20	—	3.6	—
9-10-64	21	500	7.0	78	218	15	272	6.4	—
Flatrock River - County Road South St. Paul, Indiana at USGS gaging station									
7-7-64	24	560	7.4	87	—	—	—	—	8.0

Table V-1

Raw Water Quality - Ground Water Supplies

Concentration in Miligrams Per Liter

Community	Formation	pH	Hardness mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Iron	Chlorides	Sulfates	Nitrates
Eel River Sub-Area								
Greencastle	Gravel	7.9	295-350	270-290	0.03-1.3	7	50-60	0-0.6
Brazil	Gravel	7.5	270-335	245-290	0-3.4	2-10	30-50	0-1.2
Bainbridge	Limestone	7.6	300-395	350-360	1.0 -8.0	2-57	—	Less than 1
East Fork White River Sub-Area								
New Castle	—	8.0	315-400	300-345	1.2-2.3	6-55	65-90	Less than 1
Rushville	—	7.6	270-450	240-340	0.6-3.1	5-10	60-90	Less than 2
Shelbyville	Gravel and Limestone	7.4	330-430	260-340	0.04-3.3	4-12	40-75	0-5
Edinburg	Gravel	7.4	300-340	250-280	0.3-0.5	5-10	45-60	Less than 2
Greenfield	Gravel	7.7	280-330	315-340	1.1-2.1	3-5	—	Less than 1
White River Sub-Area								
Speedway	Gravel and sand	7.5	300-390	275-315	.0-2.2	2-14	20-100	Less than 2
Lawrence	Limestone	8.3	320-365	305-350	1.2-1.7	8-38	20-35	0.1-1.2
Martinsville	Gravel	7.6	300-475	255-340	0.2-3.9	8-20	40-135	2-8
Brownsburg	Gravel	7.8	240-250	380-390	0.8-2.6	4-11	1	Less than 1
Danville	Rock	7.8	200	300-320	1.0-1.9	4-8	0	Less than 1
Alexandria	Rock	7.4	380-460	320-360	0-1.2	14	25-125	Less than 1

Table VI-1

Number and Employment Size of Manufacturing Plants

Eel River Basin Study

(Clay, Owen, and Putnam Counties, Indiana)

S. I. C.		1-19*	20-49	50-99	100-249	250-499	500-999	1,000-Over	Total
20	Food & Kindred Products	7	2						9
21	Tobacco Products	1							1
23	Apparel & Related Products				1				1
24	Lumber & Wood Products	14							14
26	Paper & Allied Products							1	1
27	Printing & Allied Products	11							11
28	Chemicals & Allied Products		1						1
30	Plastic Products			1					1
32	Stone, Clay, & Glass	5	1	1	3		1		11
33	Primary Metals				1				1
35	Non-Electrical Machinery	5							5
36	Electrical Machinery					1			1
39	Miscellaneous	2							2
	Total	45	4	2	5	1	1	1	58

* 1-19 - Plants from 1958 Census of Manufacturers; others from McGraw-Hill Survey

Source: "Location of Manufacturing Plants by County, Industry, and Employment Size, Census of Manufacturers, 1958", Bureau of the Census, U. S. Department of Commerce; McGraw-Hill Survey of Industrial Plants, 1964.

Table VI-2
Number and Employment Size of Manufacturing Plants
East Fork White River Basin
(Hancock, Henry, Rush, and Shelby Counties, Indiana)

S.I.C.		1-19*	20-49	50-99	100-249	250-499	500-999	1,000-Over	Total
20	Food & Kindred Products	27	1	1	2		1		32
22	Textile Mill Products	1			1				2
23	Apparel & Related Products	1				1			2
24	Lumber & Wood Products	10							10
25	Furniture & Fixtures	5			2				7
26	Paper & Allied Products				2	1			3
27	Printing & Allied Products	16							16
28	Chemicals & Allied Products	5				1			6
30	Plastic Products						1*		1
32	Stone, Clay, & Glass	13		1		2			16
33	Primary Metal Products		1			1	1	1	4
34	Fabricated Metal Products	10		2			1		13
35	Non-Electrical Machinery	16		4	2	1	1		24
36	Electrical Machinery		1	2	1				4
37	Transportation Equipment	1		1		1			3
38	Mechanical Measuring Devices	1							1
39	Miscellaneous	4							4
	Total	110	3	11	10	8	5	1	148

* 1-19 - Plants from 1958 Census of Manufacturers; others from McGraw-Hill Survey

Source: "Location of Manufacturing Plants by County, Industry, and Employment Size, Census of Manufacturers, 1958", Bureau of the Census, U. S. Department of Commerce; McGraw-Hill Survey of Industrial Plants, 1964.

Table VI-3

Number and Employment Size of Manufacturing Plants

White River Basin Study

(Boone, Delaware, Hamilton, Hendricks, Johnson, Madison, Marion, Morgan, and Randolph Counties, Indiana)

S.I.C.		1-19*	20-49	50-99	100-249	250-499	500-999	1,000-Over	Total
20	Food & Kindred Products	111	29	22	26	11	2	2	203
22	Textile Mill Products	1			1				2
23	Apparel & Related Products	28		1	1				30
24	Lumber & Wood Products	40			2				42
25	Furniture & Fixtures	29	1	1	4				35
26	Paper & Allied Products	6	1	2	4	5			18
27	Printing & Allied Products	164		1	10	4		1	180
28	Chemicals & Allied Products	48	14	5	10	2	1	2	82
29	Petroleum Refining	3	1	2	4	1			11
30	Plastic Products	15	4		5	1	1	2	28
31	Leather Products	2							2
32	Stone, Clay, & Glass	51		1	4	2	1	1	60
33	Primary Metals	26	13	7	4	5	2	2	59
34	Fabricated Metals	134	45	23	18	6	1	3	230
35	Non-Electrical Machinery	262	42	28	18	8	4	2	364
36	Electrical Machinery	24	5	3	5	6	1	6	50
37	Transportation Equipment	22	11	7	5	3	1	7	56
38	Mechanical Instruments	17	3	1	1	1			23
39	Miscellaneous	50	10	3	3		1		67
	Total	1,033	179	107	125	55	15	28	1,542

* 1-19 - Plants from 1958 Census of Manufacturers; others from McGraw-Hill Survey

Source: "Location of Manufacturing Plants by County, Industry, and Employment Size, Census of Manufacturers, 1958", Bureau of the Census, U. S. Department of Commerce; McGraw-Hill Survey of Industrial Plants, 1964.

Table VI-4
Output by Manufacturing Industry in Thousands of 1960 Dollars
and Index of Output 1960=100

S.I.C.	Industry Category	1960 Total Output (000)	1980 Index of Output 1960=100	2020 Index of Output 1960=100
264	Converted Paper & Paperboard Products	24,000	300	800
271	Newspapers: Publishing & Publishing Printing	209,000	500	1,000
275	Commercial Printing	693,000	300	700
324	Cement, Hydraulic	9,300	150	600
325	Structural Clay Products	16,500	180	500
335	Rolling, Drawing, & Extruding of Nonferrous Metals	4,900	180	400

This table includes counties of Clay, Owen, and Putnam, Indiana.

Source: Computed from a special employment projection study done by the Louisville District Office of the Corps of Engineers. Productivity per employee information from National Planning Association data.

Table VI-5
Output by Manufacturing Industry in Thousands of 1960 Dollars
and Index of Output 1960=100

S.I.C.	Industry Category	1960 Total Output (000)	1980 Index of Output 1960=100	2020 Index of Output 1960=100
205	Bakery Products	1,300	150	250
251	Household Furniture	10,600	110	200
263	Paperboard Mills	3,600	100	200
264	Converted Paper & Paperboard Products	10,200	300	800
265	Paperboard Containers & Boxes	5,800	200	300
283	Drugs	5,300	125	400
329	Abrasive, Asbestos, & Miscellaneous Nonmetallic Mineral Products	17,600	100	125
331	Blast Furnaces, Steel Works, & Rolling & Finishing Mills	13,300	100	100
332	Iron & Steel Foundries	6,600	200	400
344	Fabricated Structural Metal Products	1,100	200	400
367	Electronic Components & Accessories	3,500	300	700
371	Motor Vehicles & Motor Vehicle Equipment	125,200	100	200
372	Aircraft & Parts	3,000	200	500

This table includes counties of Hancock, Henry, Rush, and Shelby, Indiana.

Source: Computed from a special employment projection study done by the Louisville District Office of the Corps of Engineers. Productivity per employee information from National Planning Association data.

Table VI-6

Output of Manufacturing Industry in Thousands of 1960 Dollars and Index of Output 1960=100

S.I.C.	Industry Category	1960 Total Output (000)	1980 Index of Output 1960=100	2020 Index of Output 1960=100
201	Meat Products	47,600	200	500
234	Women's, Misses', Children's, & Infants' Under Garments	1,700	150	400
243	Millwork, Veneer, Plywood, & Prefabricated Structural Wood Products	2,300	300	600
251	Household Furniture	3,200	400	800
264	Converted Paper & Paperboard Products, Except Containers & Boxes	2,000	200	500
275	Commercial Printing	1,500	150	300
283	Drugs	103,700	300	700
306	Fabricated Rubber Products, n.e.c.	42,100	200	700
307	Miscellaneous Plastics Products	12,000	300	900
322	Glass & Glassware, Pressed or Blown	27,600	150	250
325	Structural Clay Products	2,100	100	150
332	Iron & Steel Foundries	2,800	200	400
336	Nonferrous Foundries	13,200	250	500
339	Miscellaneous Primary Metal Industries	9,200	150	300
342	Cutlery, Hand Tools, & General Hardware	12,400	200	400
343	Heating Apparatus (except electric) & Plumbing Fixtures	9,100	100	200
345	Screw Machine Products, & Bolts, Nuts, Screws, Rivets, & Washers	3,200	300	600
352	Farm Machinery & Equipment	1,400	400	1,200
361	Electric Transmission & Distribution Equipment	13,100	300	600
362	Electrical Industrial Apparatus	7,000	300	500
364	Electric Lighting & Wiring Equipment	80,600	300	700
365	Radio & Television Receiving Sets, Except Communication Types	104,000	100	200

Table VI-6
Output of Manufacturing Industry in Thousands of 1960 Dollars
and Index of Output 1960=100 (cont'd)

S.I.C.	Industry Category	1960 Total Output (000)	1980 Index of Output 1960=100	2020 Index of Output 1960=100
366	Communication Equipment	152,900	150	300
367	Electronic Components & Accessories	600	1,000	2,000
369	Miscellaneous Electrical Machinery, Equipment, & Supplies	241,200	300	900
371	Motor Vehicles & Motor Vehicle Equipment	652,100	250	500
372	Aircraft & Parts	665,300	200	600

This table includes counties of Boone, Delaware, Hamilton, Hendricks, Johnson, Madison, Marion, Morgan, and Randolph, Indiana.

Source: Computed from a special employment projection study done by the Louisville District Office of the Corps of Engineers. Productivity per employee information from National Planning Association data.

Table VI-7
Historical and Projected Study Area Population

	1950	1960	1980	2020
Eel River Subarea				
Clay County	23,918	24,207	28,000	40,800
Brazil Urban Area	8,434	8,853	13,000	21,000
Owen County	11,763	11,400	9,700	10,400
Putnam County	22,950	24,927	32,100	40,900
Greencastle Township	9,453	10,542	12,000	18,000
Subtotal	58,631	60,534	69,800	92,100
East Fork White River Subarea				
Hancock County	20,332	26,665	36,800	66,900
Center Township	7,989	11,356	17,000	35,000
Henry County	45,505	48,899	60,800	105,600
Henry Township	23,633	25,896	34,000	60,000
Rush County	19,799	20,393	20,000	24,200
Rushville Township	8,090	9,131	11,500	14,500
Shelby County	28,026	34,093	33,500	46,900
Addison Township	13,857	16,904	19,000	25,000
Subtotal	113,662	130,050	151,100	243,600
White River Subarea				
Boone County	23,993	27,543	25,600	43,700
Lebanon Urban Area	7,714	9,650	10,600	24,000
Delaware County	90,252	110,938	157,800	244,800
Muncie Urban Area	58,479	77,504	126,000	220,000
Hamilton County	28,491	40,132	47,200	71,900
Noblesville Township	9,125	11,651	13,000	15,000
Clay Township	2,311	10,215	20,000	43,000

Table VI-7
Historical and Projected Study Area Population (cont'd)

	1950	1960	1980	2020
White River Subarea (cont'd)				
Hendricks County	24,594	40,896	50,600	101,800
Guilford, Lincoln, and Washington Townships	9,758	22,817	33,000	73,000
Johnson County	26,183	43,704	63,000	108,700
Franklin Township	8,429	10,578	14,000	19,000
Pleasant Township	5,211	14,282	26,000	75,000
Madison County	103,911	125,819	194,600	296,200
Anderson Township	57,023	67,305	100,000	150,000
Marion County	551,777	697,567	895,600	1,206,500
Morgan County	23,726	33,875	33,400	58,500
Brown Township	3,181	5,673	7,500	21,000
Washington Township	8,625	10,912	15,000	20,000
Randolph County	27,141	28,434	32,400	46,500
Wayne Township	4,890	5,332	6,500	10,000
White River Township	7,935	8,403	9,500	13,000
Urbanized Area of Indianapolis*	517,343	676,439	900,000	1,300,000
Subtotal	900,068	1,148,908	1,500,200	2,178,600
Study Area Total	1,072,361	1,339,492	1,721,100	2,514,300

*Marion County plus the surrounding townships of Clay in Hamilton County; Guilford, Lincoln, and Washington in Hendricks County; and Pleasant in Johnson County.

Table VII-1
MUNICIPAL WATER SUPPLIES

Location and Name of Municipality	Estimated Population Served - 1963	Average Use MGD	Demand gpcd
Eel River Subarea			
Greencastle	9,000	1.2	133
Brazil[1] [2]	10,450	1.0	96
Jasonville	4,300	0.187	43
Bainbridge	600	0.03	50
North Salem	650	0.022	34
Jamestown	830	0.03	36
Clay City	960	0.045	47
Cloverdale	760	0.035	46
Putnamville State Farm	1300	0.31	240
Subarea Total	28,850	2.86	99
East Fork White River Subarea			
Franklin	8,000	1.1	138
Greenfield	11,000	1.1	100
New Castle	21,000	1.65	78
Shelbyville	12,500	1.59	127
Rushville	7,000	0.70	100
Edinburg	4,000	0.60	150
New Whiteland	3,490	0.20	57
Princes Lake[3]	570	0.08	140
Whiteland	1,000	0.10	100
Knightstown	2,500	0.35	140
Lewisville	650	0.037	57
Shirley	1,040	0.05	48
Spiceland	865	0.017	20
Carthage	1,100	0.16	145
Morristown	800	0.039	49
St. Paul	500	0.030	60
Subarea Total	76,000	7.8	103

Table VII-1 (Cont'd)
MUNICIPAL WATER SUPPLIES

Location and Name of Municipality	Estimated Population Served - 1963	Average Use MGD	Demand gpcd
White River Subarea 4			
Indianapolis	615,000	75.5	123
Speedway	10,500	1.7	162
Lawrence	10,200	0.9	87
Clermont	1,100	0.055	50
Cumberland	900		
Whitestown	650	0.025	39
Brownsburg	5,000	0.35	70
Danville	3,500	0.35	100
Pittsboro	830	0.03	36
Plainfield	6,000	0.32	53
Mooresville	4,000	0.26	65
Greenwood	4,000	0.5	125
Bargersville	650	0.087	134
Bethany	65	0.003	46
Brooklyn	850	0.03	35
Martinsville	8,000	0.76	95
Noblesville	8,000	0.75	94
Cicero	1,290	0.06	47
Sheridan	1,260	0.159	126
Carmel	1,440	0.17	118
Westfield	1,250	0.075	60
Zionville	1,900	0.126	66
Fortville	2,300	0.22	96
Pendleton	2,500	0.13	32
Elwood	13,000	0.905	70
Tipton	5,600	0.60	107
Arcadia	1,260	0.05	40
Winchester	5,740	0.50	87
Farmland	1,200	0.08	67
Parker City	1,200	0.065	54
Muncie	71,000	11.50	162
Yorktown	1,200	0.069	58
Gaston	810	0.03	37
Mt. Summit	400	0.025	63
Middletown	2,100	0.18	86
Chesterfield	2,500	0.20	80
Anderson	62,000	9.03	146
Edgewood	2,120	0.20	94
Summitville	900	0.08	89
Alexandria	5,580	0.70	125
Frankton	1,450	0.20	138
Orestes	450	0.025	56
Lapel	1,780	0.08	45
Subarea Total	873,000	107.6	123

Table VII-1 (Cont'd)
MUNICIPAL WATER SUPPLIES

Sources: "1963 Inventory of Municipal Water Facilities, U. S. Department of Health, Education, and Welfare."
"Data on Indiana Water Supplies, Bulletin No. S. E. 10., Indiana State Board of Health, 1960."

1. Brazil also serves the communities of Harmony and Knightsville.

2. Jasonville also serves the communities of Coalmont and Hymera.

3. Princes Lake also serves the community of Ninevah.

4. Indianapolis also serves the communities of Beech Grove, Ben Davis, Homecroft, Mars Hill, Meridian Hills Southport, Warren Park and Williams Creek. Figures for Indianapolis are for year 1964.

All communities utilize wells as their source of supply except Indianapolis, Speedway, Princes Lake, Muncie, Anderson and Putnamville State Farm. Indianapolis in addition to their surface supply from White River and Fall Creek has 42 wells utilized as an emergency and occasional source of supply. Estimated ground water use by the Indianapolis Water Company is an average of 3 mgd. Princes Lake uses impoundments, Putnamville State Farm uses a low head impoundment on Deer Creek. Muncie uses low head impoundments on Buck Creek and White River along with a 21,500 acre-foot impoundment on Prairie Creek, supplemented by wells. Anderson uses wells supplemented by a low head impoundment on White River. Speedway uses a low head impoundment on Big Eagle Creek and has six wells for emergency use.

Table VIII-1

Municipal Waste Treatment Facilities

Community	Sewage Treatment Facilities	Receiving Stream	Estimated Population Served	Population Equivalent Based on B.O.D. Raw	Population Equivalent Based on B.O.D. Treated
Eel River Subarea					
Jamestown	Sewers No Treatment	West Fork Big Walnut Ck.	800	800[E]	800[E]
North Salem	"	East Fork Big Walnut Ck.	600	600[E]	600[E]
Greencastle	Secondary	Big Walnut Ck.	8,500	8,500[E]	1,275
Brazil	Secondary	Birch Creek	8,800	8,800[E]	1,320
Cloverdale	Secondary	Rabbit Creek	740	740[E]	110
Putnamville State Farm	Secondary	Deer Creek	1,300	1,300[E]	200[E]
Jasonville	Secondary	Trib. to Eel R.	2,430	2,430[E]	360[E]
		Total	23,170	23,170	4,665
East Fork White River Subarea					
New Castle	Secondary	Big Blue R.	20,000	21,200	2,970
Carthage	Secondary	Big Blue R.	1,000	1,000[E]	150[E]
Morristown	Oxidation Ponds	Big Blue R.	705	705[E]	105[E]
Shelbyville	Secondary	Big Blue R.	14,300	7,820	2,885
Edinburg	Secondary	Big Blue R.	3,660	3,660[E]	550[E]
Greenfield	Secondary	Brandywine Ck.	9,000	9,000[E]	1,350[E]
Franklin	Secondary	Youngs Creek	9,450	13,695	1,060
New Whiteland	Secondary	Grassy Creek	3,480	3,480[E]	520[E]
Rushville	Secondary	Flat Rock R.	7,260	2,885	220
Shirley	Oxidation Ponds	Six Mile Ck. to Big Blue R.	1,030	1,030[E]	150[E]
Spiceland	Sewers No Treatment	Tributary to Big Blue River	867	860[E]	860[E]
Knightstown	"	Big Blue River	2,490	2,490[E]	2,490[E]
New Palestine	"	Big Sugar Ck.	600	600[E]	600[E]
Glenwood	"	Ben Davis Ck.	380	380[E]	380[E]
		Total	74,215	68,805	14,290

Table VIII-1 (Cont'd)

Municipal Waste Treatment Facilities

Community	Sewage Treatment Facilities	Receiving Stream	Estimated Population Served	Population Equivalent Based on B.O.D. Raw	Treated
White River Subarea					
Winchester	Secondary	White River	5,740	5,740[E]	870[E]
Parker City	Sewers No Treatment	White River	1,180	1,180[E]	1,180[E]
Muncie	Secondary	White River	68,600[1]	153,000[E]	26,000[E]
Yorktown	Primary	" "	1,130	1,130[E]	790[E]
Chesterfield	Primary	" "	2,585	2,585[E]	1,810[E]
Anderson	Secondary	" "	63,000	54,330	11,640
Edgewood	Sewers No Treatment	Tributary White River	2,110	2,110[E]	2,110[E]
Summitville	Sewers No Treatment	Mud Creek	1,045	1,045[E]	1,045[E]
Gaston	Secondary	Pipe Creek	770	770[E]	115[E]
Alexandria	Secondary	" "	5,200	5,200[E]	790[E]
Elwood	Secondary	Duck Creek	11,000	2,820	1,055
Lapel	Secondary	Stony Creek	1,770	1,770[E]	265[E]
Carmel	Secondary	Cool Creek	1,440	1,440[E]	215[E]
Westfield	Oxidation Ponds	" "	1,210	1,210[E]	180[E]
Zionsville	Secondary	" "	1,820[E]	1,820[E]	275[E]
Middletown	Secondary	Fall Creek	2,030	2,220	410
Pendleton	Secondary	" "	2,470	2,400[E]	300[E]
Fortville	Secondary	" "	2,200	2,200[E]	330[E]
Lawrence	Secondary	" "	10,100	9,990	1,445
Beech Grove	Secondary	Lick Creek	10,950	5,575	310

Table VIII-1 (Cont'd)

Municipal Waste Treatment Facilities

Community	Sewage Treatment Facilities	Receiving Stream	Estimated Population Served	Population Equivalent Based on B.O.D. Raw	Treated
Clermont	Sewers No Treatment	Eagle Creek	1,050	1,050	1,050[E]
Noblesville	Secondary	White River	7,800	3,300[E]	180[E]
Indianapolis	Secondary	White River	476,260	1,310,000	202,700
Speedway	Secondary	Eagle Creek	9,600	5,365	1,690
Homecroft	Sewers No Treatment	Little Buck Creek	950	950[E]	950[E]
Southport	Sewers No Treatment	Little Buck Creek	890	890[E]	890[E]
Brownsburg	Secondary	White Lick Ck.	4,475[E]	4,475[E]	670[E]
Danville	Secondary	West Fork White Lick Ck.	3,200	3,200[E]	480[E]
Plainfield	Secondary	White Lick Ck.	5,460	5,460[E]	820[E]
Mooresville	Secondary	White Lick Ck.	3,800	3,800[E]	570[E]
Greenwood	Secondary	Pleasant Run	7,170	4,405	695
Tipton	Secondary	Cicero Creek	5,600	5,600	840[E]
Arcadia	Sewers No Treatment	Cicero Creek	1,260	1,260[E]	1,260[E]
Cicero	Sewers No Treatment	Cicero Creek	1,280	1,280[E]	1,280[E]
Sheridan	Secondary	Cicero Creek	2,165	2,165	325[E]
Bargersville	Secondary	Stotts Creek	580	580[E]	90[E]
Martinsville	Primary	White River	7,500	7,195	5,225
		Total	735,390	1,619,510	270,850

Footnotes:

1. Wastes of 53,715 given secondary treatment and 14,885 no treatment.

E. Indicates an estimated value.

Table VIII-2

Industrial Waste Treatment Facilities
(Self-discharging industrial waste treatment facilities for industrial plants utilizing over 10 million gallons of water a year)[1]

S.I.C. Code	Type of Plant & Location	Employment (1962)	Pop. Equiv. Based on B.O.D.
Eel River Subarea			
	None self-discharging and over 10 mg/yr.		
East Fork White River Subarea			
2653	Pulp and paper mill-Carthage[2]	160	28,000
3229	Fiberglass products-Shelbyville[3]	32	900
2834	Biologicals-Greenfield[4]	300	50
White River Subarea			
2834	Biologicals-Zionsville[5]	400	120
2814 2491	Wood treating and coal tar chemicals-Indianapolis[6]	150	2,800
2911	Petroleum refinery-Indianapolis[7]	220	1,080
2041	Corn milling-Indianapolis[8]	130	5,950
3713 3461	Truck body parts-Indianapolis[8]	3,500	420
3351	Brass products-Indianapolis[9]	1,200	280
3722 3531 3729	Aircraft engines and products-Indianapolis[10]	4,300	1,500
		Total	41,100

Footnotes:

1. Plants whose discharge is essentially only cooling water or which have wastes not characterized as producing a B.O.D. are not included.

Table VIII-2 (Cont'd)

Industrial Waste Treatment Facilities
(Self-discharging industrial waste treatment facilities for industrial plants utilizing over 10 million gallons of water a year)[1]

Footnotes cont'd.

2. Paper machine water is discharged to clarifier and lagoon. Results are for combined wastes of boiler blowdown, log washing and power plant cooling waters. Since collection of these data, extensive waste treatment facilities have been added. Effluent is discharged to Big Blue River.

3. Sanitary wastes and starch and chrome binder wastes are discharged to the municipal sewer system. Effluent is discharged to Little Blue River.

4. Treatment is by a trickling filter plant with postchlorination. Effluent is discharged to Brandywine Creek via Leary Ditch.

5. Wastes from animal quarters are treated by Imhoff tank followed by slow sand filtration. Serum area and cafeteria wastes are given activated sludge treatment and sand filtration. Effluent is discharged to Eagle Creek.

6. Process wastes are treated in API (American Petroleum Institute) separator and effluent is discharged to Eagle Creek. Has connected to municipal sewer since these data were collected.

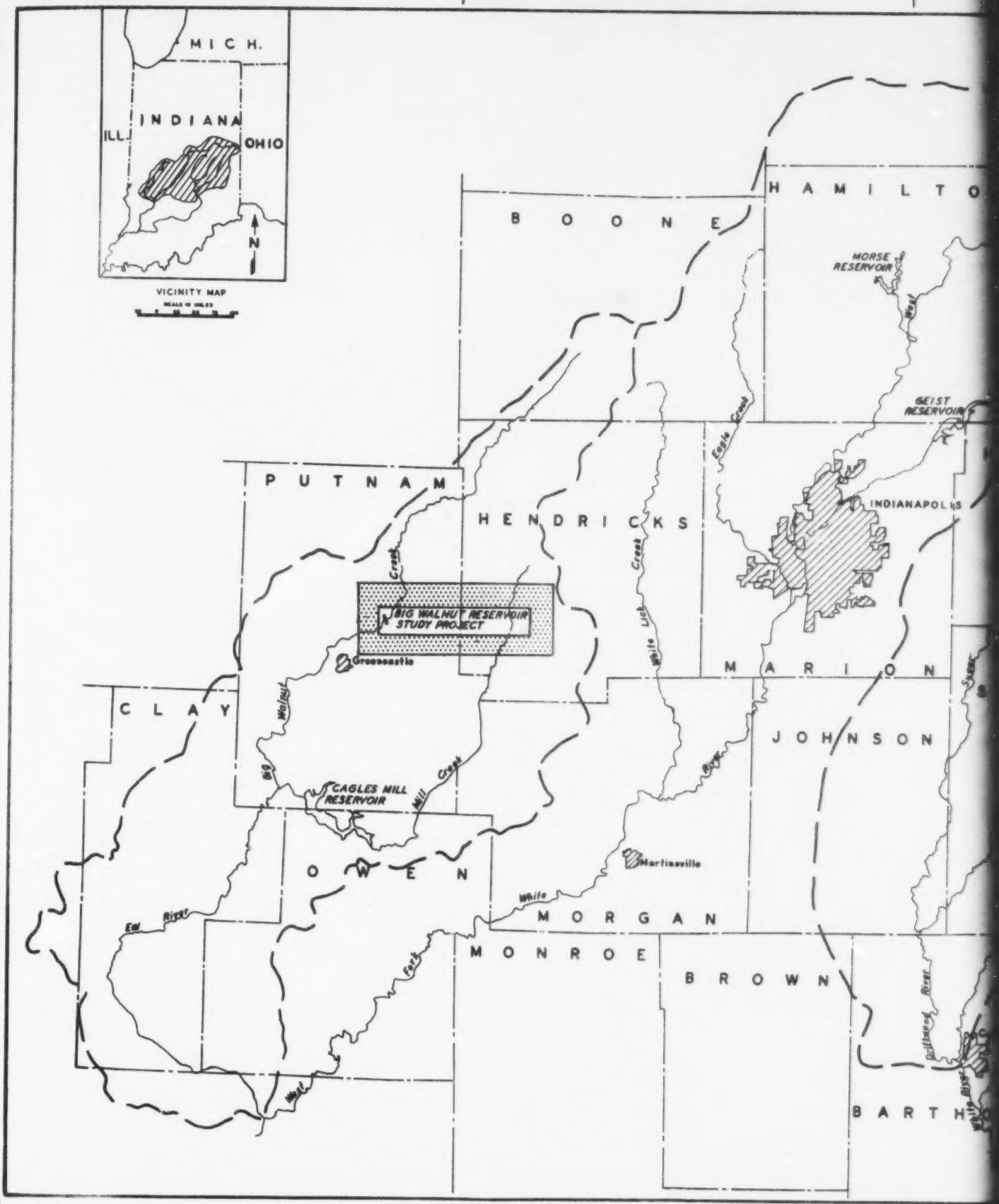
7. Treatment consists of ion exchange tower for phenols, sulfides and flue gas. Process water is treated in an API separator, accelator and oxidation ponds. Effluent is discharged to Little Eagle Creek.

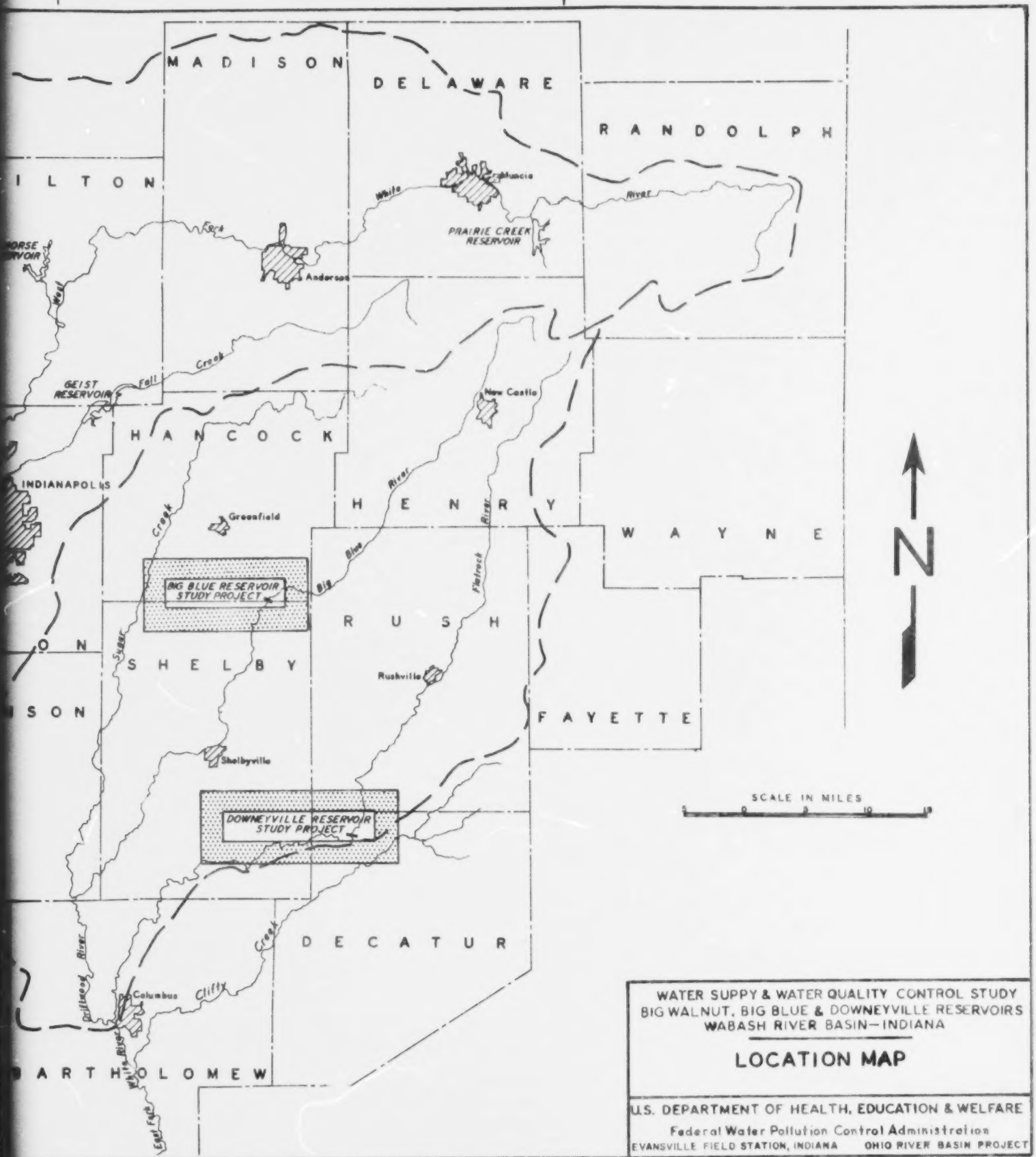
8. Sanitary wastes are discharged to municipal sewer system. Process and cooling waters receive no treatment. Effluent is discharged to the White River.

9. All wastes are treated in an aerated lagoon preceded by an oil skimming basin. Effluent is discharged to Eagle Creek.

10. Sanitary wastes are discharged to municipal sewer system. Process wastes are treated by three API separators, clarifiers, chemical treatment and a stabilization pond. Effluent is discharged to Eagle Creek.

11. Data obtained from joint U. S. Public Health Service-Indiana State Board of Health survey in 1962 and 1963.


MICH.
INDIANA
ILL.
OHIO
N
VICINITY MAP
BOONE
HAMILTO
MORSE RESERVOIR
GEIST RESERVOIR
Eagle Creek
PUTNAM
HENDRICKS
INDIANAPOLIS
Creek
White Lick Creek
BIG WALNUT RESERVOIR STUDY PROJECT
Greencastle
MARION
CLAY
Big Walnut
JOHNSON
CAGLES MILL RESERVOIR
Mill Creek
Martinsville
OWEN
White River
MORGAN
Eel River
MONROE
BROWN
Fork
Mill
Driftwood River
BARTHO

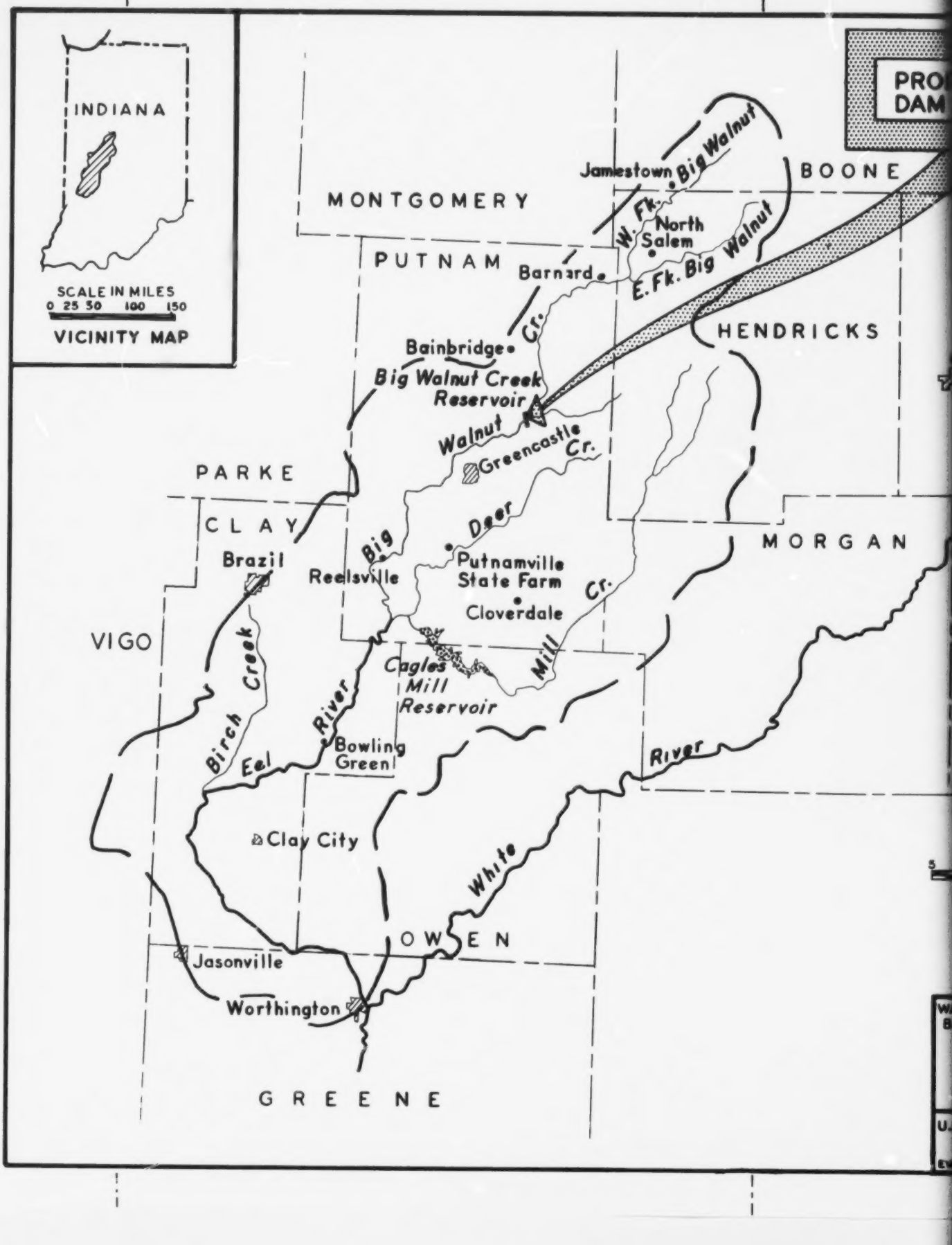


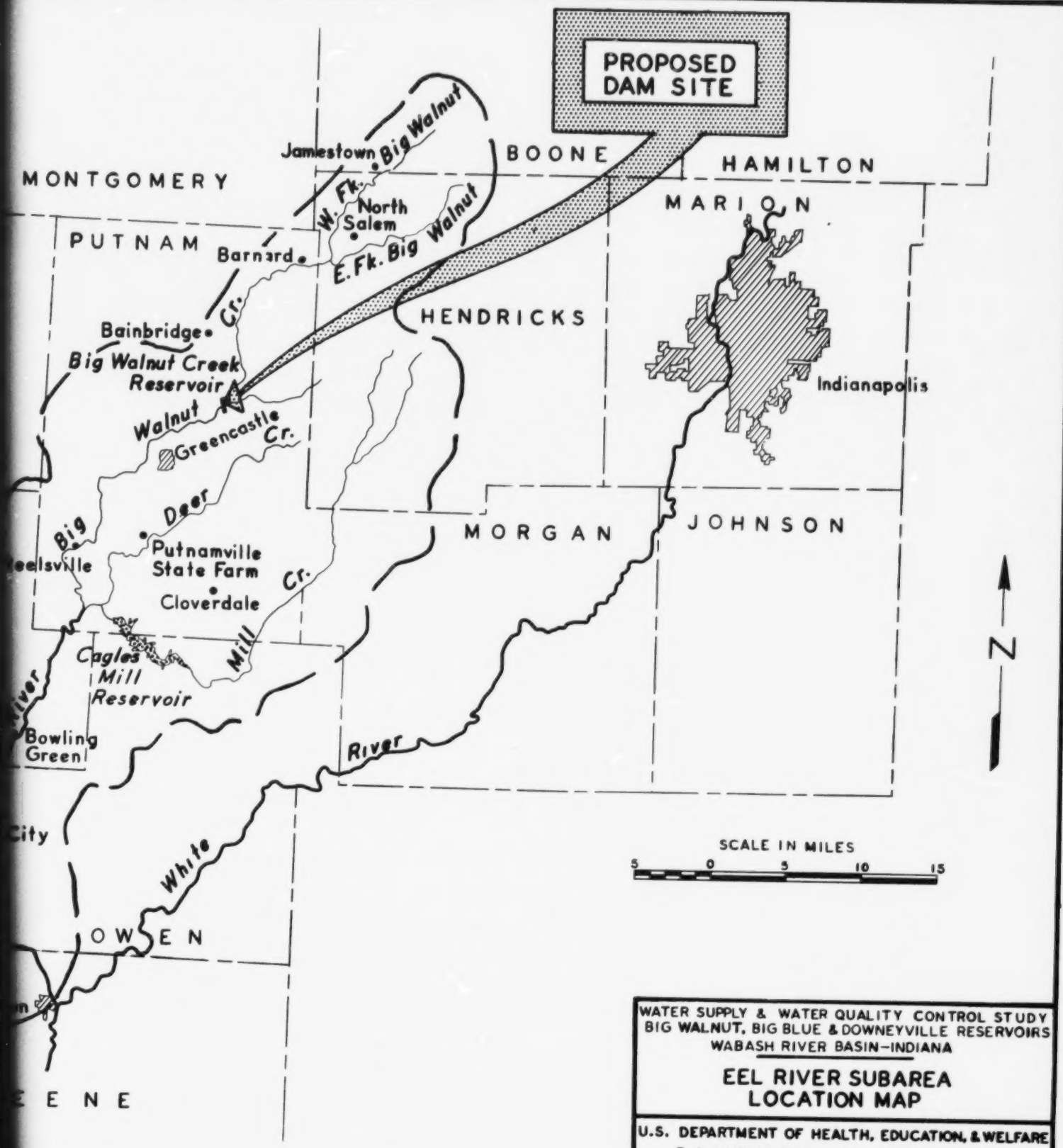
WATER SUPPY & WATER QUALITY CONTROL STUDY
BIG WALNUT, BIG BLUE & DOWNEYVILLE RESERVOIRS
WABASH RIVER BASIN—INDIANA

LOCATION MAP

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
Federal Water Pollution Control Administration
EVANSVILLE FIELD STATION, INDIANA OHIO RIVER BASIN PROJECT

FIGURE I


INDIANA
SCALE IN MILES
0 25 50 100 150
VICINITY MAP
PRO
DAM
MONTGOMERY
BOONE
Jamestown
Big Walnut
W. Fk.
North Salem
E. Fk. Big Walnut
PUTNAM
Barnard
Cr.
Bainbridge
HENDRICKS
Big Walnut Creek Reservoir
Walnut
Greencastle
Cr.
PARKE
CLAY
Big
Deer
MORGAN
Brazil
Reelsville
Putnamville State Farm
Cloverdale
Cr.
VIGO
Birch Creek
Eel
River
Cagles Mill Reservoir
Mill
Bowling Green
River
Clay City
White
OWEN
Jasonville
Worthington
GREENE

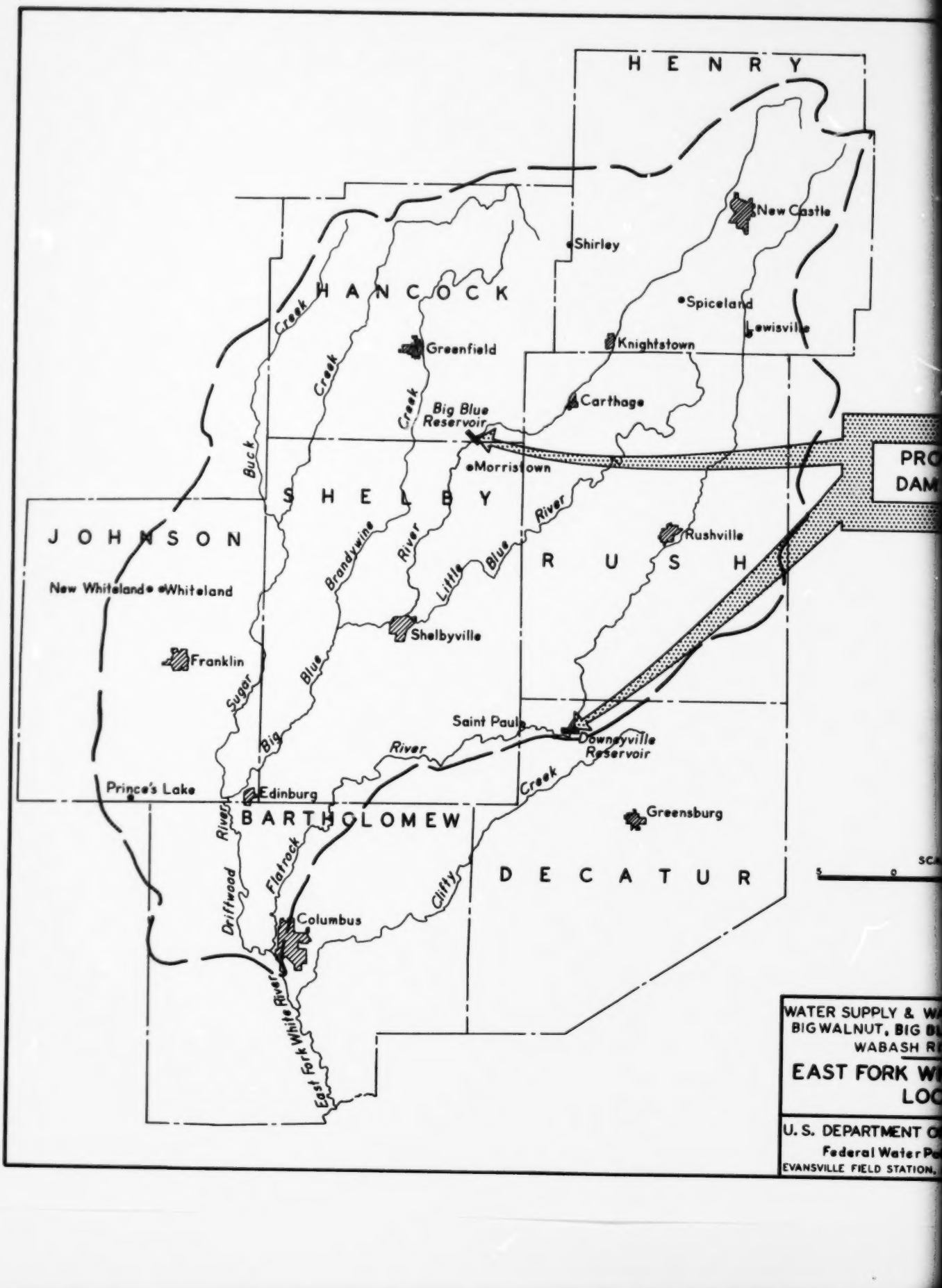


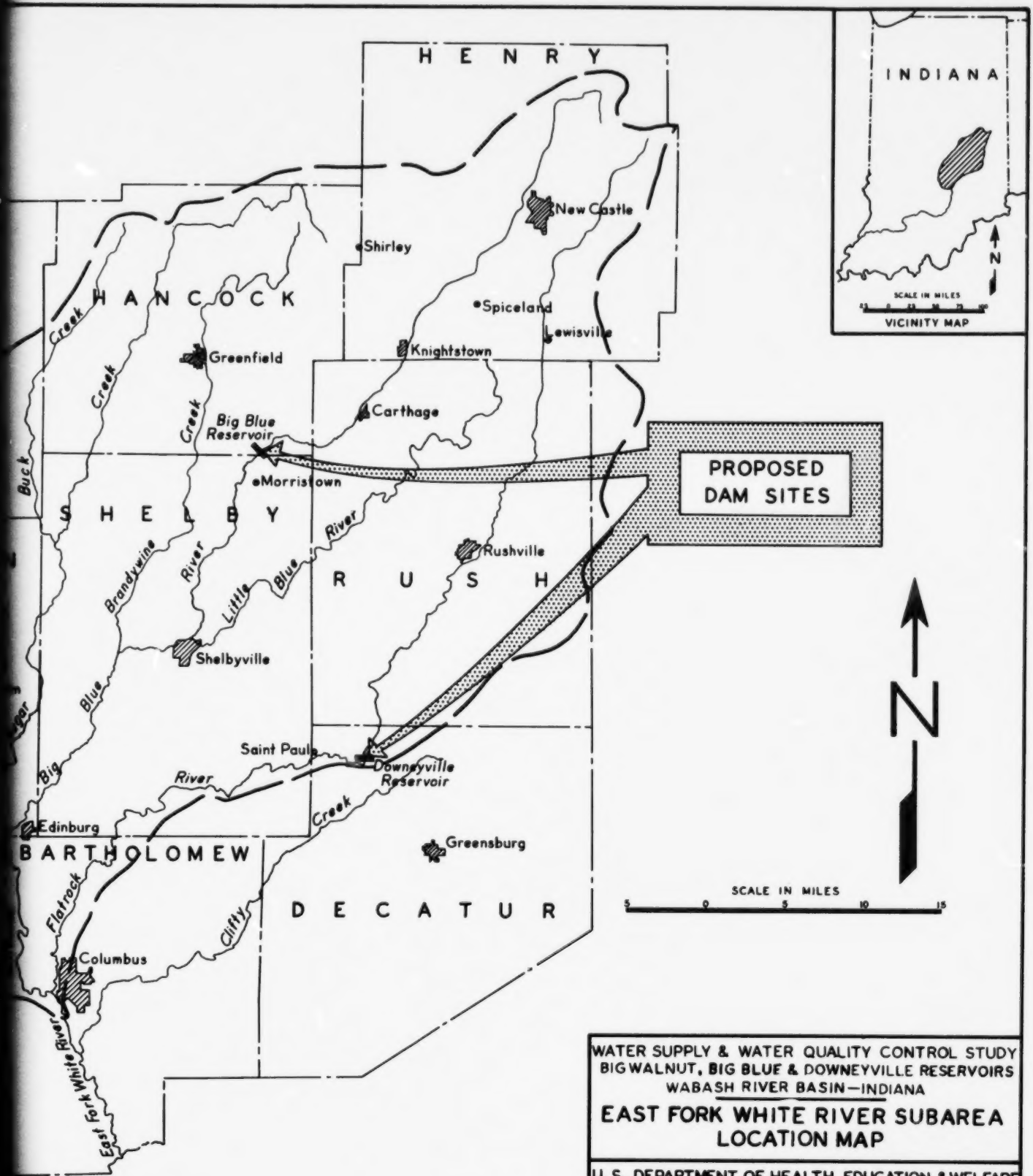
WATER SUPPLY & WATER QUALITY CONTROL STUDY
BIG WALNUT, BIG BLUE & DOWNEYVILLE RESERVOIRS
WABASH RIVER BASIN—INDIANA

EEL RIVER SUBAREA LOCATION MAP

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Federal Water Pollution Control Administration
EVANSVILLE FIELD STATION, INDIANA OHIO RIVER BASIN PROJECT

FIGURE II


HENRY
HANCOCK
SHELBY
JOHNSON
RUSH
BARTHOLOMEW
DECATUR
New Castle
Shirley
Spiceland
Lewisville
Knightstown
Greenfield
Carthage
Big Blue Reservoir
Morristown
Rushville
New Whiteland
Whiteland
Shelbyville
Franklin
Saint Paul
Downeyville Reservoir
Prince's Lake
Edinburg
Greensburg
Columbus
Buck Creek
Brandywine Creek
Big Blue River
Little Blue River
Sugar Creek
Big Blue River
Driftwood River
Flatrock River
Clifty Creek
East Fork White River
PRO
DAM
WATER SUPPLY & WA
BIG WALNUT, BIG BL
WABASH RI
EAST FORK WH
LOC
U. S. DEPARTMENT O
Federal Water Po
EVANSVILLE FIELD STATION,

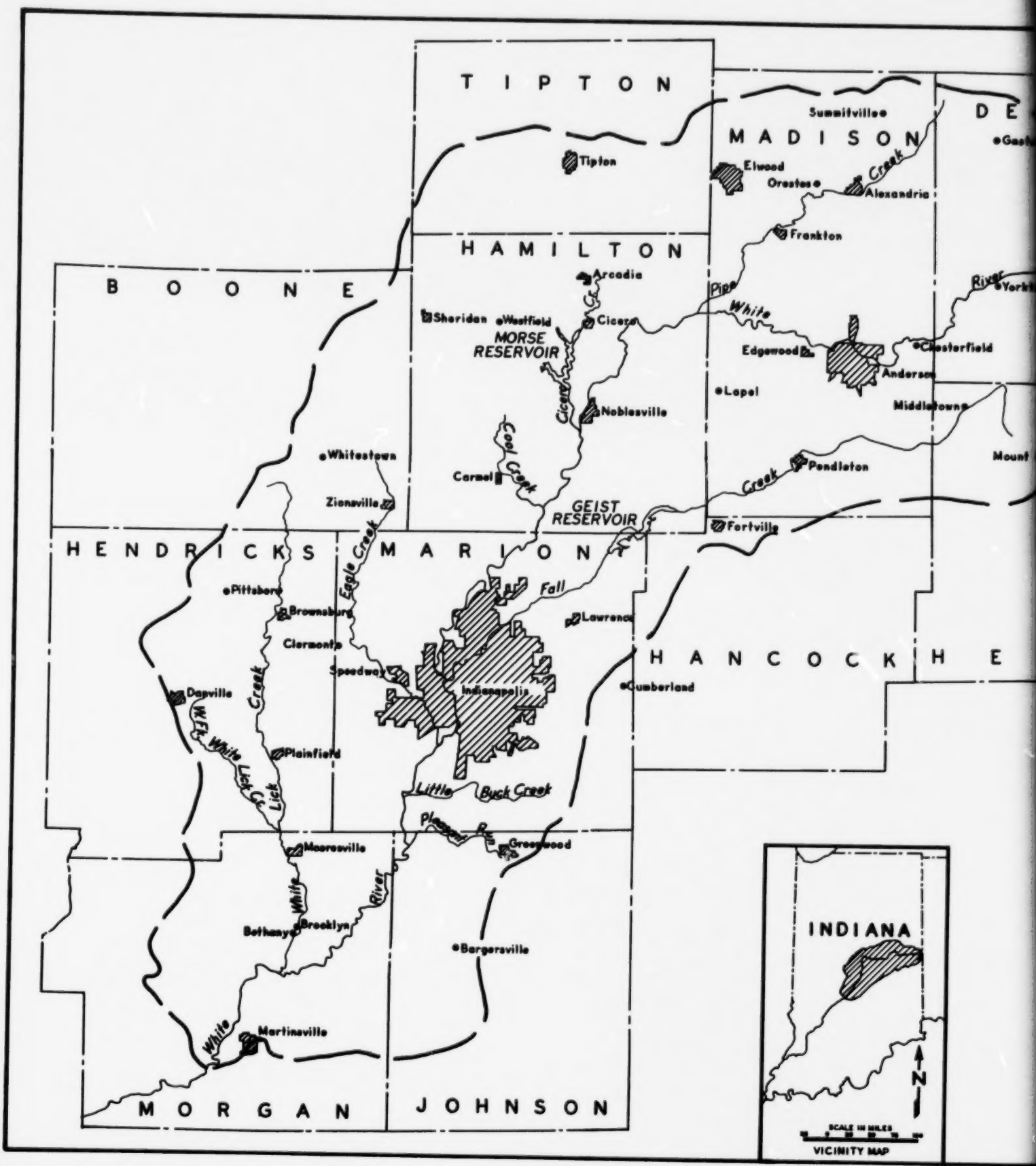


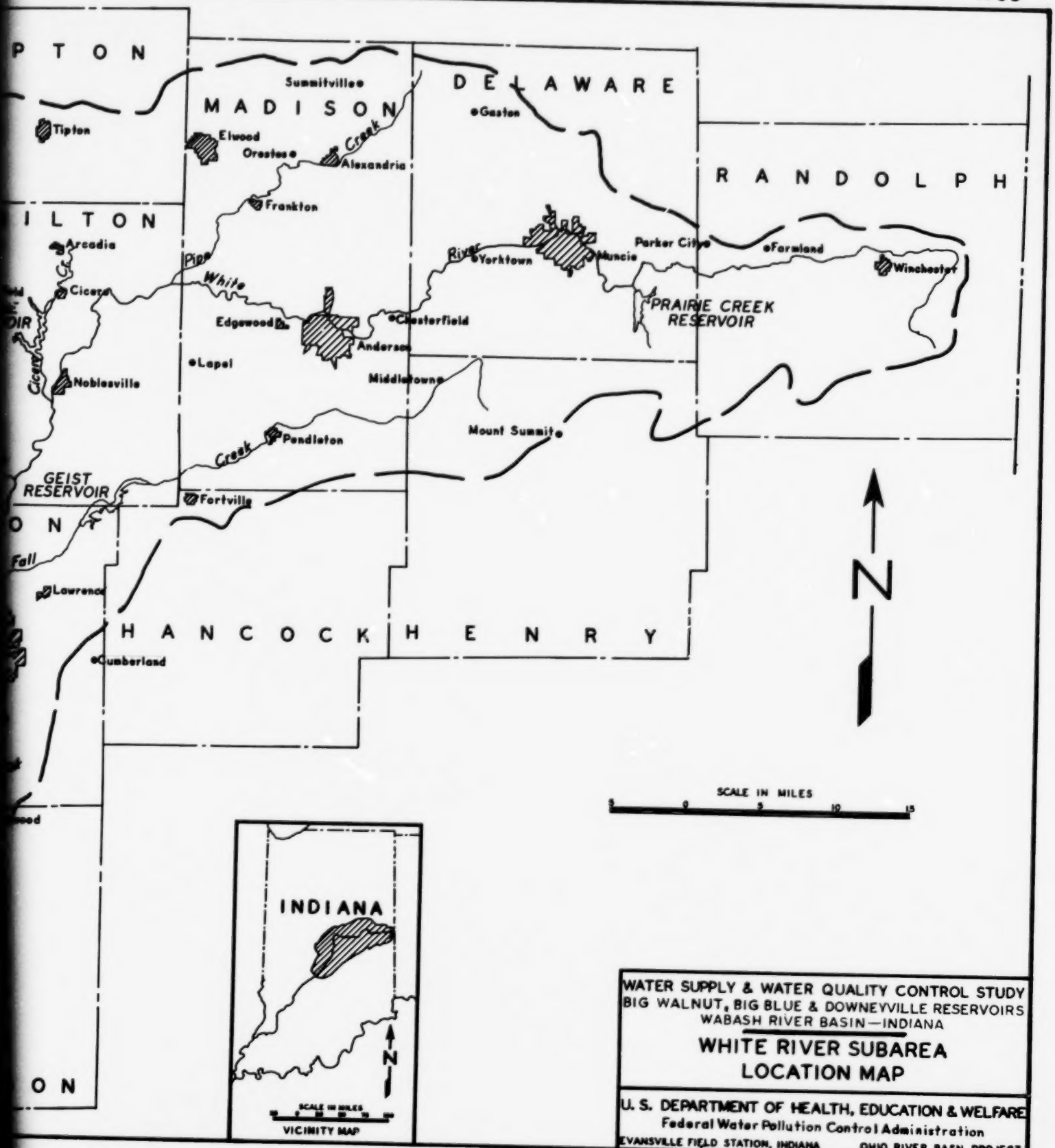
WATER SUPPLY & WATER QUALITY CONTROL STUDY
BIG WALNUT, BIG BLUE & DOWNEYVILLE RESERVOIRS
WABASH RIVER BASIN—INDIANA

EAST FORK WHITE RIVER SUBAREA
LOCATION MAP

U. S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
Federal Water Pollution Control Administration
EVANSVILLE FIELD STATION, INDIANA — OHIO RIVER BASIN PROJECT

FIGURE III


TIPTON
MADISON
HAMILTON
BOONE
HENDRICKS
MARION
HANCOCK
MORGAN
JOHNSON
Tipton
Summitville
Elwood
Orestes
Alexandria
Frankton
Arcadia
Sheridan
Westfield
Cicero
MORSE RESERVOIR
Noblesville
Edgewood
Anderson
Lapel
Middletown
Whitestown
Zionsville
Carmel
Pendleton
GEIST RESERVOIR
Fortville
Pittsboro
Brownsburg
Clermont
Speedway
Indianapolis
Lawrence
Cumberland
Danville
Plainfield
Mooresville
Greenwood
Bethany
Brooklyn
Bargersville
Martinsville
Eagle Creek
White Lick Creek
Little Buck Creek
White River
Fall
Pipe
Cicero
Cool Creek
INDIANA
N
SCALE IN MILES
VICINITY MAP

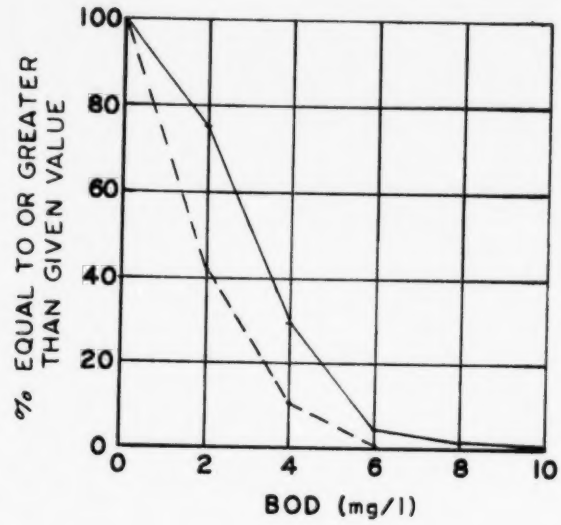


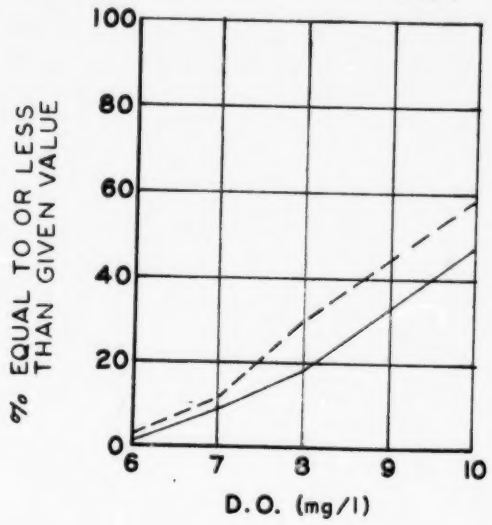
WATER SUPPLY & WATER QUALITY CONTROL STUDY
BIG WALNUT, BIG BLUE & DOWNEYVILLE RESERVOIRS
WABASH RIVER BASIN—INDIANA

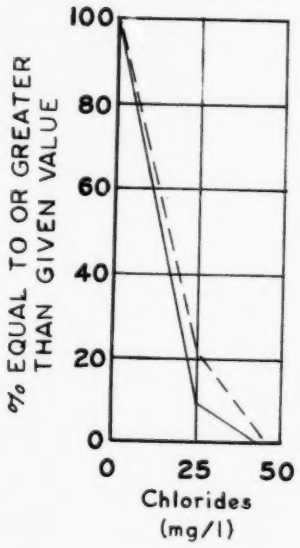
WHITE RIVER SUBAREA
LOCATION MAP

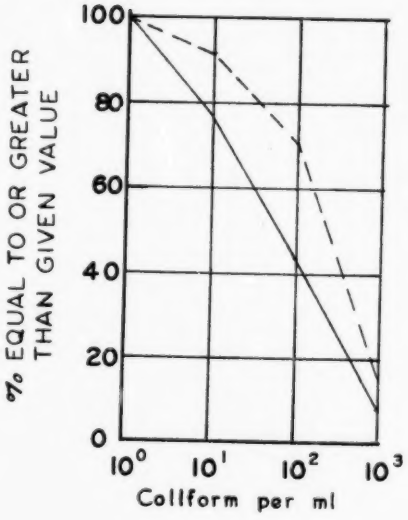
U. S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
Federal Water Pollution Control Administration
EVANSVILLE FIELD STATION, INDIANA — OHIO RIVER BASN PROJECT

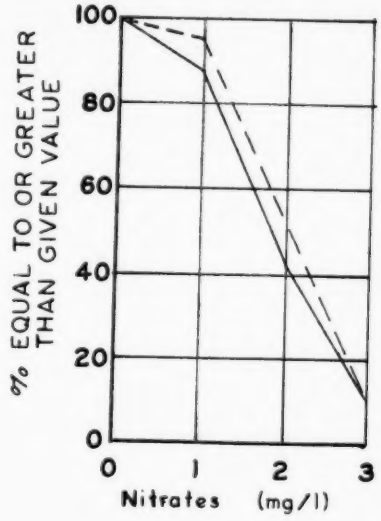
FIGURE IV











LEGEND

SHELBYVILLE ——

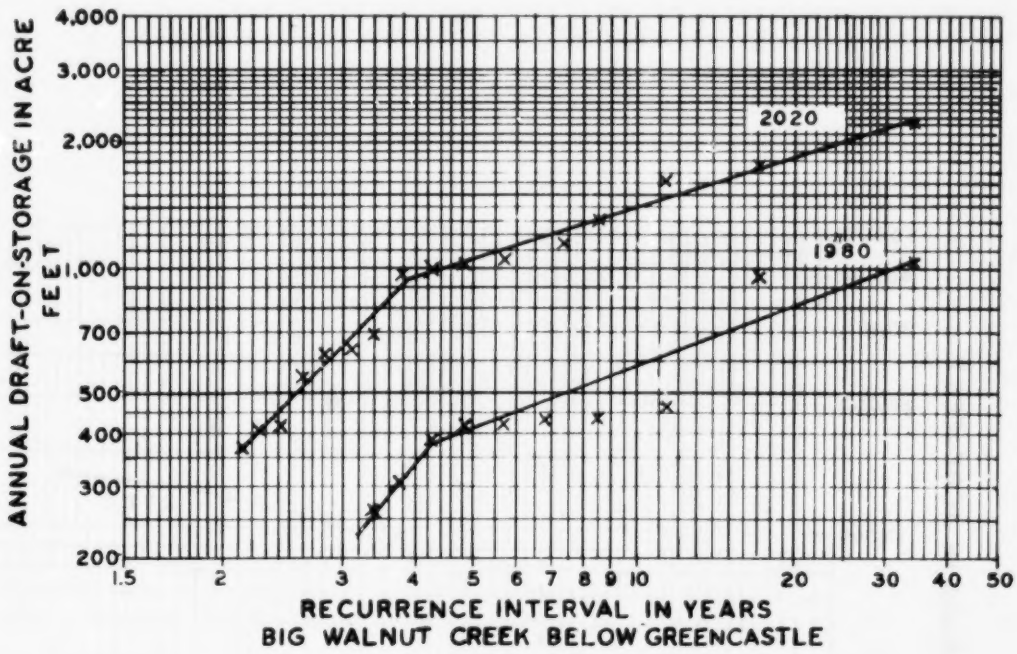
CARTHAGE - - - - - -

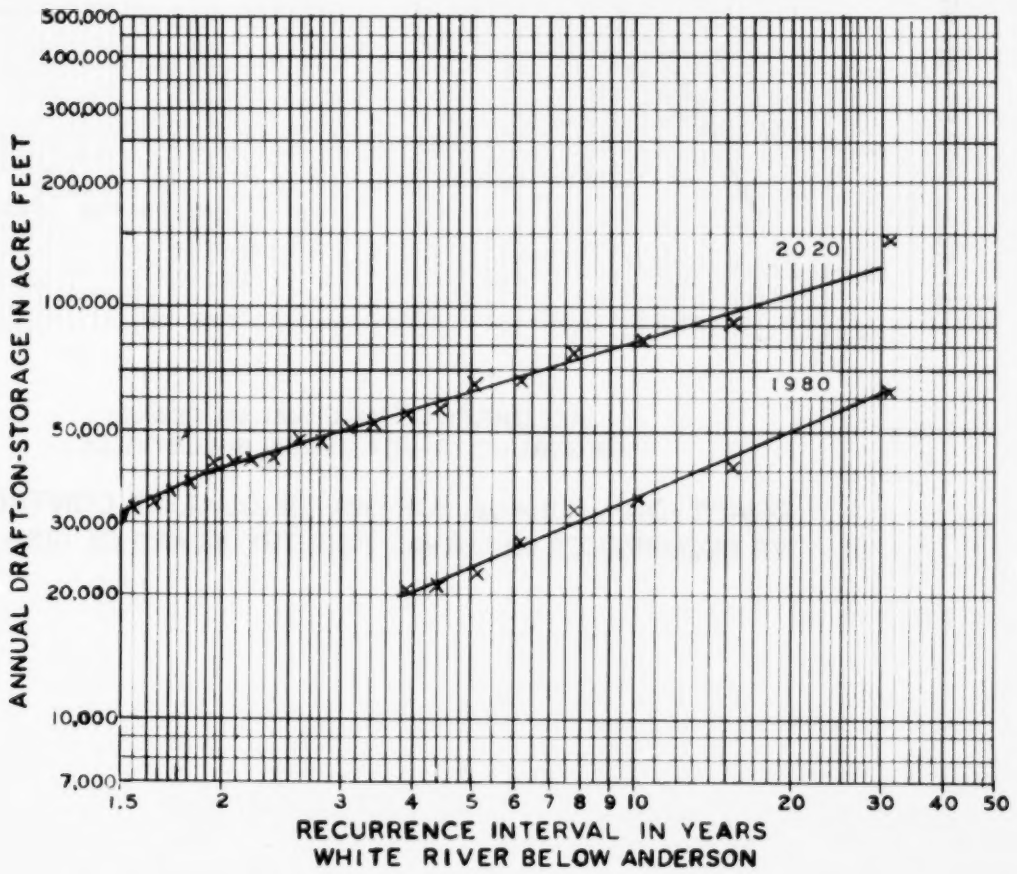
NOTE:

THE ABOVE PER CENT OCCURENCES REPRESENT ABOUT 195 SAMPLES AT EACH STATION, EQUALLY DISTRIBUTED THROUGHOUT THE YEAR.

PERCENT OCCURENCE FOR SHELBYVILLE AND CARTHAGE, INDIANA WATER QUALITY MONITOR STATIONS 1957-1964

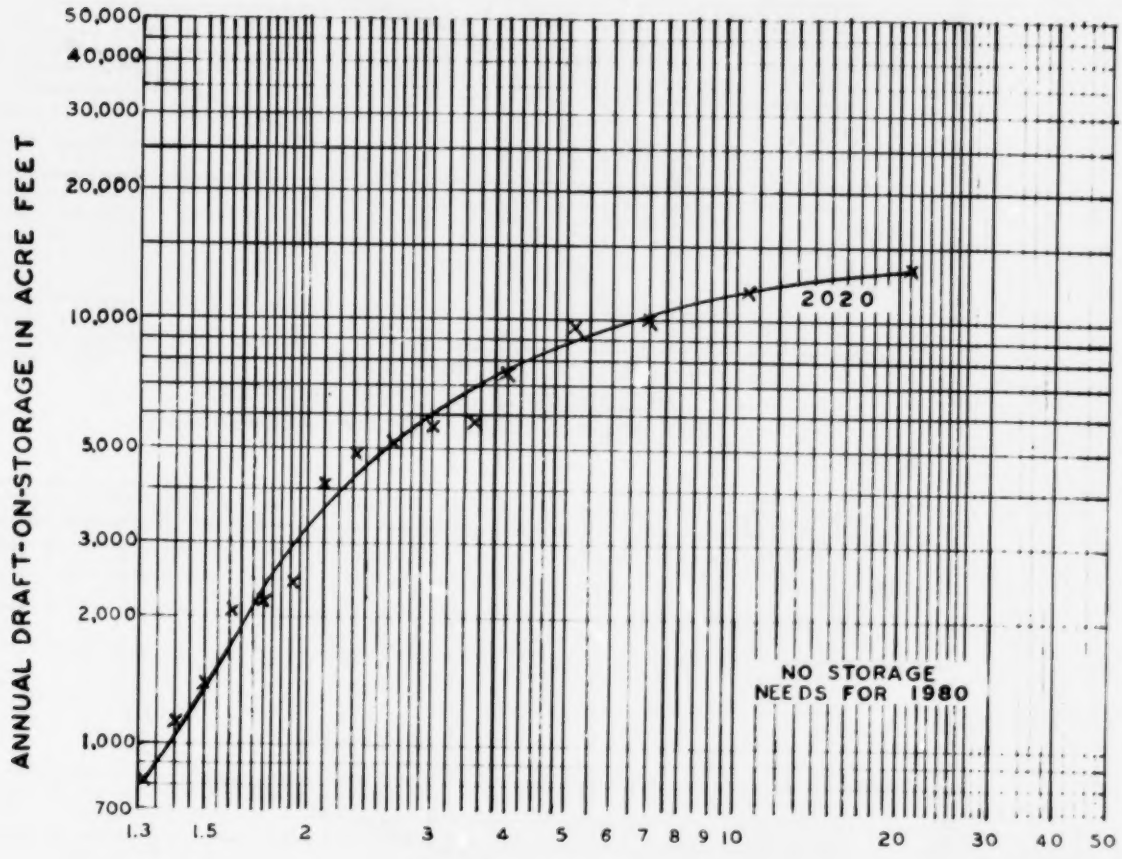
FIGURE V





DRAFT-ON-STORAGE FOR WATER QUALITY CONTROL NEEDS
VS RECURRENCE INTERVAL FOR THE YEARS OF 1980 AND 2020

FIGURE VI



DRAFT-ON-STORAGE FOR WATER QUALITY CONTROL NEEDS
VS RECURRENCE INTERVAL FOR THE YEARS OF 1980 AND 2020

FIGURE VII